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水稻香米品種臺農秈20號之育成[1]

楊遜謙[2]　張萬來[3]　趙政男[2]　陳隆澤[2]

摘要　臺農秈20號爲本省經雜交育成之秈型香米品種，具有濃芳之香味，米質優良，並抗稻熱病，褐飛蝨等病蟲害，株高一期作109.3公分，二期作115.0公分；每株穗數一期作16.1支，二期作12.4支；全生育日數一期作143天，二期作107天；粒型中長稍細，米粒富光澤，心腹白少，直鏈性澱粉含量18.5%，種子稍具休眠性，稻穀產量根據區域試驗結果，平均每公頃一期作爲6,061公斤，二期作爲5,371公斤，一期作在高屏地區較高產，二期作在褐飛蝨易發生地區都適合栽培。

本品種耐寒性較差，一期作不宜過早育苗及插秧，以免秧苗受寒害，又本品種較易脫粒，在沿海季節風較大地區避免種植，以免脫粒損失，香米之香味爲揮發性，因此貯藏時最好放置通風良好之涼冷地方。

香米（Aromatic rice或Scented rice）具有濃芳之香味，古今中外都受廣大消費者歡迎，香米之栽培地區主要以亞洲爲主，如印度，巴基斯坦、泰國、馬來西亞、越南、日本等國家。香米之品質受品種及地域之影響，有些地區種出來的香味較差，如巴基斯坦生產之Basmati香米在Pun Ja地區生產者爲上品，在其他地區栽培者缺少香味[(4)]，因此香米的栽培面積有限，多數國家生產量無法滿足內銷之需求，因此香米市價比一般食米高出很多。本省過去只有在山地種植少許，山胞在喜慶節日慶祝時食用，平地少有種植，近年來因國民生活水準之提升，一般消費者對良質米之需求頗切，因此稻米品質之改良爲水稻育種之重要目標，本分所鑒於香米日受廣大消費者之歡迎，於民國66年開始著手香米育種工作，經多年來選育與試驗於民國75年育成臺農秈20號香米品種，該品種粒型中長稍細，心腹白少，米質佳，直鏈性澱粉含量低，米質與蓬萊米很相似，很受消費者之歡迎，在食米多元化之今日，希望本品種能帶給消費者有較多之選擇機會。

材料與方法

一、育成經過：

臺農秈20號原品系名爲嘉農秈育43號，爲民國68年第二期作以(嘉農秈８號× IR841—33—1—3)×嘉農系比662137雜交組合的 F_4 單株與嘉農系比671178雜交(圖一)，民國69年第一期作 F_1 以單本種植，69年第二期作F_2採集團單本植約 2,000個體並選出85個體進入F_3世代，系統分離每系統種40個體，並於 F_4～F_5世代同時篩選稻熱病及褐飛蝨之抗性，稻熱病之檢定採用旱田式病圃[(5)]，褐飛蝨檢定採幼苗檢定法[(6)][(7)]並在第五世代採其劍葉並切成碎片，以1.7%KOH 溶液浸漬10分鐘後聞其香味進行香味之篩選[(1)]，在 F_5 世代選出嘉農系比712021等品系參加民國71年二期作初級品系產量比較試驗

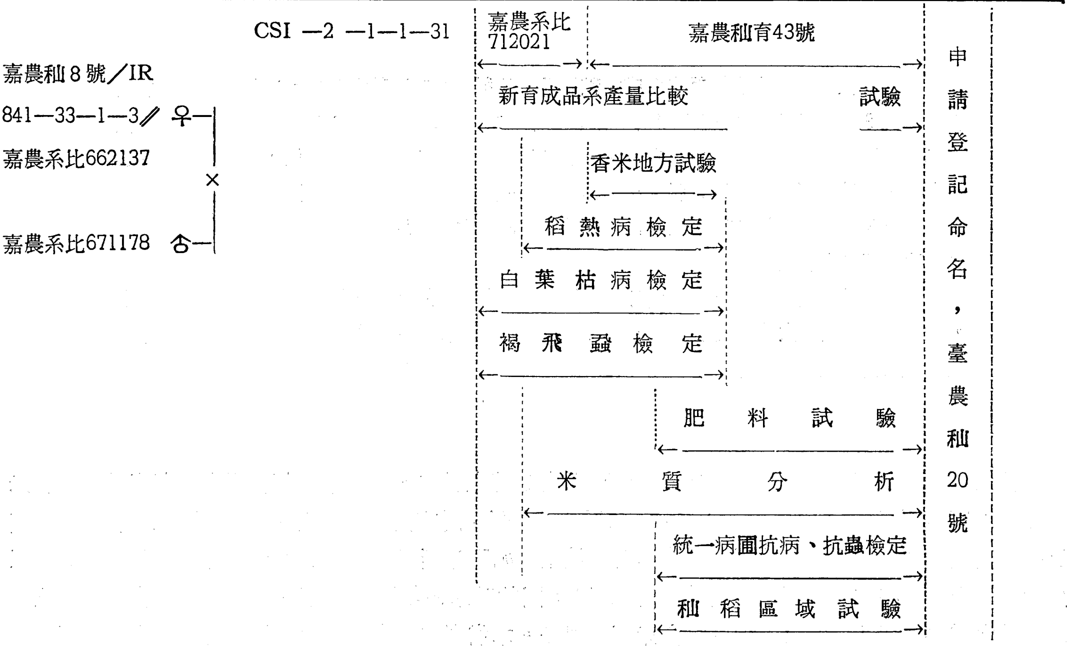
1.臺灣省農業試驗所　研究報告第1428號。

2.嘉義農業試驗分所助理研究員。臺灣省　嘉義市。

3.嘉義分所前農藝系主任。臺灣省　嘉義市。

圖1.臺農秈20號之系統圖

年期 / 世代 / 雜交親本	六十八		六十九		七十		七十一		七十二		七十三		七十四		七十五	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
		雜交	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}



，並同時參加本分所各項抗病抗蟲檢定，表現均佳，翌年進行高級品系產量比較試驗二年，並在72年第二期作及73年第一期作以嘉農秈育43號品系名參加香米地方試驗，肥料試驗，73年一期作起參加二年四期作之秈稻區域試驗[1]，及統一病圃抗病抗蟲性檢定，米質分析等試驗，結果都有良好表現[2][3]，臺農秈20號米質優良香味濃芳並具有抗多種病蟲害之優良特性，於民國75年一期作申請命名登記，經審查小組審查通過，正式命名為臺農秈20號。

二、親本特性：

1. 母本：為（嘉農秈8號× IR841—33—1—3）×嘉農系比662137之 F_4 世代具有良質濃芳之香味。
2. 父本：為嘉農系比671178具有抗褐飛蝨及抗稻熱病品質優良之特性。

三、品種特性：

臺農秈20號株高一期作109.3公分，二期作115.0公分；每株穗數一期作16.1支，二期作12.4支；全生育日數一期作143天，二期作107天；具有濃芳之香味並抗稻熱病及褐飛蝨等病蟲害，區域試驗結果，其稻穀平均產量一期作6,061 kg/ha，二期作 5,371 kg/ha；本品種之特徵為生育期間葉鞘及葉緣帶紫色，柱頭及稃尖亦均帶紫色，同時生育期間在田間發散出香味與其他品種較易判別（表一）。

圖2. 臺農秈20號之系譜圖

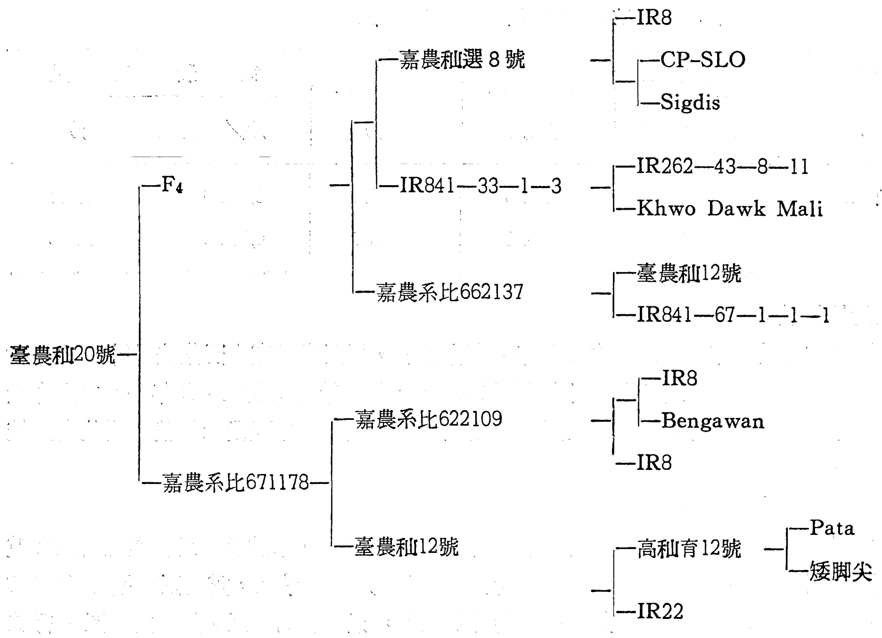


表1. 臺農秈20號之品種特性表

品種名稱	育成經過 親本 ♀×♂	育成經過 什交年代	育成經過 選出年代	類型	期作別	苗期病害	成熟期 株高(公分)	成熟期 穗數(支)	稈色	芒	柱頭色	稃色 生育期	稃色 成熟期	稃尖色 抽穗期	稃尖色 成熟期	全生育日數(日)	抗病性 葉稻熱病	抗病性 穗稻熱病	抗病性 紋枯病	抗病性 白葉枯病	抗蟲性 褐飛蝨	倒伏程度	穗長(公分)	穗重(公克)	一穗粒數(粒)	千粒量(公克)	脫粒性	休眠性	耐肥性	稔實率(%)	糙米率(%)	米質	高級試驗 公頃穀產量(公斤)	高級試驗 指數(%)	高級試驗 對照品種	區域試驗 公頃穀產量(公斤)	區域試驗 指數(%)	區域試驗 對照品種
臺農秈20號	嘉農系比662137//嘉農秈8號/IR841—33-1—3///嘉農系比671178	68 II	71 I	秈型	I	無	一〇九·三	一六·一	紫	無	紫	無	無	紫	紫	一四三	抗	抗	感	中抗	抗	直	二二·六	三·四四	一五八·四	二一·〇	中	輕微	重	九二·〇	七八·九	上	七六五〇	一一九·七	嘉農秈11號	六一〇二	八六·九	臺中秈3號
					II	無	一一五·〇	一二·四								一〇七	抗	抗	感	抗~中抗	抗		二五·〇	三·七一	一七七·三	二一·四				九四·八	七九·〇		六三七八	一〇四·五		五二六〇	一一四·七	

註：區域試驗成績民國73年、74年兩年平均。

結果與討論

一、歷年各項產量試驗成績

1.初級品系產量比較試驗

本品種於民國71年第二期作參加初級品系產量比較試驗，供試品系爲系比712021等88品系，以臺農秈14號爲對照，行株距 25×20cm，行長 4m，4 行區，小區面積 4m²，二重複，試驗結果如表二，臺農秈20號不但具有濃芳的香味，稻穀產量與對照品種臺農秈14號相似，並具有稻熱病及褐飛蝨等

之抗性，於72年第一期作進行高級試驗。

表2. 臺農秈20號之初級品系產量比較試驗

期作	品種（系）名稱	生育日數（日）插秧至抽穗	株高（公分）	穗數（穗）	稻穀產量 公斤／公頃	稻穀產量 %
71年二期	臺農秈20號	71	106.3	11.8	6,525.0	100.4
	臺農秈14號（CK）	74	104.1	8.7	6,500.0	100.0

2.高級品系產量比較試驗

高級品系產量比較試驗於72年一、二期作及73年一期作辦理，採用逢機完全區集法設計（RCBD），重複四次，行株距25×20cm，4行區，小區面積爲 $4m^2$ ，試驗結果如表三，72年一、二期作產量比對照品種高，73年一期作及74年二期作對照品種改爲新育成豐產品種之臺農秈14號，因此產量較對照臺農秈14號略差。

3.臺農秈20號之耐肥性檢定試驗

爲了解本品種之耐肥性，乃於民國73及74年進行二年四作肥料試驗，本試驗採用普通肥料區與重肥區二處理，普肥區採氮 (N)80，磷酐（P_2O_5）80，氧化鉀(K_2O) 80 kg/ha，重肥區爲氮（N）160 磷酐（P_2O_5）120，氧化鉀（K_2O）120 kg/ha，採用裂區設計，以肥料爲主區，品種爲副區，行株距25×20cm，5行區，每行20株，小區面積 $5m^2$，試驗結果如表四，由二年四期作結果顯示，增肥

表3. 臺農秈20號之高級品系產量比較試驗

期作	品種（系）名稱	生育日數（日）插秧至抽穗	生育日數（日）插秧至成熟	株高（公分）	穗數（穗）	穗長（公分）	穗重（公克）	一穗粒數（粒）	千粒重（公克）	稔實率（%）	每公頃穀產量 穀產量（公斤）	每公頃穀產量 指數（%）	每公頃穀產量 糙米（公斤）	碾米率（%）	糙米品質
72年一期	臺農秈20號	113	143	109.3	16.1	23.9	3.53	160.3	22.5	92.6	7,650.0	119.7	6,035.9	78.9	上
	嘉農秈11號（CK）	106	137	84.9	16.7	22.0	3.26	150.6	22.0	91.4	6,393.8	100.0	5,134.2	80.3	中
72年二期	臺農秈20號	72	115	115.0	12.4	25.0	3.71	177.3	21.4	94.8	6,378.1	104.5	5,038.7	79.0	上
	嘉農秈11號（CK）	72	110	100.3	13.3	22.9	3.48	166.0	21.0	93.2	6,103.1	100.0	4,815.3	78.9	中
73年一期	臺農秈20號	117	140	95.9	15.5	23.2	2.77	143.1	22.3	92.5	6,512.5	96.9	5,144.9	79.0	上
	臺農秈14號（CK）	116	138	94.8	16.9	24.2	3.20	118.2	26.0	90.6	6,718.8	100.0	5,328.0	79.3	中
74年二期	臺農秈20號	73	114	105.7	15.7	26.3	4.01	201.2	21.2	91.9	6,365.6	94.7	4,997.0	78.5	上
	臺農秈14號（CK）	76	116	106.9	16.5	24.8	4.18	158.5	27.0	86.5	6,721.9	100.0	5,343.9	79.5	中

效果比普通肥料效果佳，由此可知臺農秈20號在重肥時始能發揮生產潛力。

4.香米地方試驗（農委會73農建—2.1—產—115計畫在6個地區進行）。

爲了解香米在地方之適應性由農委會補助，於民國72年第二期作及73年第一期作在嘉雲地區（嘉義、溪口、民雄、新港、西螺鹿場，西螺埔心或大新等六個試地）進行地方適應性試驗。試驗結果如表五，第二期作除嘉義及西螺二處產量比對照品種略差外，其他三個地區都比對照品種高，第一期作

除溪口及新港之地區外，其他四個地區產量都較高，由期作別看來，地方與期作之間表現雖然不盡一致，但產量除溪口地方地力較瘠產量不及6,000 kg/ha外，其他各地區均達6,000 kg/ha以上。就香米地方試驗之資料進行穩定性測定，結果如圖三、四。由穩定性測定得悉，本品種雖非最高產品系，但其稻穀產量仍高於對照品種及參試品種（系）之平均值，且表現相當穩定。

5.秈稻區域試驗（臺中區農業改良場綜合整理）

臺農秈20號（嘉農秈育43號）參加民國73及74年二年四期作之秈稻區域試驗，本試驗是在臺中區農業改良場（彰化大村），臺南區農業改良場嘉義分場（嘉義），及高雄區農業改良場（屏東）等三個地區辦理，根據試驗結果（表六），本試驗對照品種為臺中秈3號，該品種為當時栽培面積較大之高產良質品種，根據表六結果臺農秈20號一、二期作生育日數與臺中秈3號差異不大，株高較臺中秈3號高，穗數較臺中秈3號少，由不同期作年度間產量表現來看，73年一期作嘉義地區較差，而74年一期作在各地區產量都不如對照品種，但二期作無論在不同年度及地方之間，均表現優異成績，尤其在大村地區比對照臺中秈3號超過 42.2%（73年2期作）及 29.3%（74年2期作），在屏東亦超過

表4. 臺農秈20號耐肥性檢定試驗

肥料	期作	年度	品種（系）名稱	株高（公分）	穗數（穗）	生育*日數（日）	穗長（公分）	穗重（公克）	一穗粒數（粒）	千粒重（公克）	稔實率（%）	稻穀產量 公斤／公頃	稻穀產量 %	稻穀產量 %
普肥區	一期	73	臺農秈20號	97.4	10.6	115	23.2	2.71	139.2	22.3	86.7	6,025	94.5	100.0
			臺農秈14號（CK）	96.3	15.5	114	21.9	2.67	100.7	27.5	92.9	6,375	100.0	100.0
		74	臺農秈20號	107.8	12.7	94	25.1	3.36	157.5	26.7	91.2	6,850	91.3	100.0
			臺農秈14號（CK）	106.1	13.6	96	24.9	3.79	139.6	28.0	96.2	7,506	100.0	100.0
	二期	73	臺農秈20號	116.2	11.6	73	26.5	4.29	213.3	20.6	92.8	6,704	90.5	100.0
			臺農秈14號（CK）	116.3	13.1	73	24.8	4.28	158.6	27.1	94.5	7,406	100.0	100.0
		74	臺農秈20號	104.4	11.0	73	23.4	3.00	153.4	21.1	86.5	5,356	89.6	100.0
			臺農秈14號（CK）	110.3	13.3	80	24.7	3.57	141.6	26.8	93.1	5,981	100.0	100.0
重肥區	一期	73	臺農秈20號	99.5	12.9	116	22.4	2.45	128.2	20.4	90.0	6,475	99.4	109.5
			臺農秈14號（CK）	96.8	17.2	115	21.2	2.38	85.8	27.9	93.6	6,513	100.0	102.2
		74	臺農秈20號	107.3	16.3	95	25.6	3.52	180.1	20.7	91.1	6,881	80.2	100.5
			臺農秈14號（CK）	108.7	18.5	97	25.4	3.83	142.9	23.7	94.7	8,575	100.0	114.2
	二期	73	臺農秈20號	114.6	13.0	74	25.5	4.14	190.6	21.2	93.5	6,956	97.8	103.8
			臺農秈14號（CK）	113.3	16.8	75	24.8	3.75	154.1	24.7	94.7	7,113	100.0	96.0
		74	臺農秈20號	106.0	11.8	72	24.0	3.38	163.5	21.4	91.5	5,713	83.5	106.7
			臺農秈14號（CK）	113.5	13.9	79	24.6	3.70	140.5	27.2	95.1	6,844	100.0	114.4

註：生育日數係插秧至抽穗日數。
普肥區肥料施用量為N：P_2O_5：K_2O＝80：80：80公斤／公頃。
重肥區肥料施用量為N：P_2O_5：K_2O＝160：120：120公斤／公頃。

表5. 臺農秈20號香米地方試驗

期作	品種（系）名稱	地點	生育日數(日)插秧至抽穗	株高(公分)	穗數(穗)	穗長(公分)	穗重(公克)	一穗粒數(粒)	千粒重(公克)	稔實率(%)	稻穀產量 公斤／公頃	稻穀產量 %
七十二年第二期作	臺農秈20號	溪口	67.5	102.4	9.8	24.2	3.37	177.0	19.1	91.6	4,993	105.7
		嘉義	66.0	115.2	13.9	26.5	4.17	199.1	21.3	93.3	7,510	97.8
		民雄	65.0	112.0	14.2	25.1	3.68	179.3	20.3	93.9	6,500	109.8
		新港	72.3	119.6	15.2	25.3	3.43	180.0	18.9	94.7	7,270	103.6
		西螺埔心	70.3	126.0	14.2	24.5	3.07	155.3	19.4	91.9	6,945	98.5
		西螺鹿場	68.5	116.1	13.6	25.2	3 64	173.7	21.5	94.2	6,900	98.2
		平均	68.0	115.2	13.5	25.1	3.56	177.4	20.1	93.3	6,686.3	101.8
	嘉農秈11號（CK）	溪口	68.3	87.2	11.1	21.7	2.65	127.6	22.0	91.2	4,723	100.0
		嘉義	69.0	104.8	14.3	23.2	4.16	175.0	24.3	91.7	7,680	100.0
		民雄	65.0	99.9	21.6	22.2	3.26	140.3	23.6	93.4	5,920	100.0
		新港	77.3	102.4	18.0	21.4	3.08	158.0	21.6	90.0	7,020	100.0
		西螺埔心	74.8	104.3	15.8	22.6	3.34	155.1	22.4	90.7	7,050	100.0
		西螺鹿場	76.5	97.1	14.8	22.1	3.07	132.0	24.7	88.6	7,030	100.0
		平均	72.0	99.3	15.9	22.2	3.26	148.0	23.1	90.9	6,570.4	100.0
七十三年第一期作	臺農秈20號	溪口	126	105.1	13.8	24.1	2.27	119.1	21.0	83.8	5,673	91.9
		嘉義	114	107.7	13.8	23.9	3.05	154.6	22.1	85.8	6,700	106.3
		民雄	99	115.9	17.0	26.4	3.33	185.2	19.2	83.8	7,450	111.2
		新港	109	114.5	14.2	24.9	3.25	164.0	22.5	85.4	6,900	94.5
		西螺鹿場	95	112.3	16.4	26.7	3.23	182.1	18.4	84.1	7,600	109.4
		西螺大新	100	114.4	15.7	24.0	2.85	143.7	21.2	88.4	6,700	104.7
		平均	107	111.7	15.2	25.0	3.00	158.1	20.7	85.2	6,837.2	103.0
	嘉農秈11號（CK）	溪口	121	89.4	17.4	20.1	2.77	118.4	24.3	94.2	6,175	100.0
		嘉義	108	91.9	17.3	21.0	3.04	122.8	27.3	89.7	6,300	100.0
		民雄	97	95.3	18.4	21.9	3.25	138.2	24.2	89.9	6,700	100.0
		新港	102	87.4	19.2	20.7	3.12	129.3	25.3	94.7	7,300	100.0
		西螺鹿場	90	85.5	19.3	21.5	3.18	134.5	22.8	96.0	6,950	100.0
		西螺大新	91	89.4	22.2	21.3	2.83	118.0	25.1	91.8	6,400	100.0
		平均	102	89.8	19.0	21.1	3.03	126.9	24.8	92.7	6,637.6	100.0

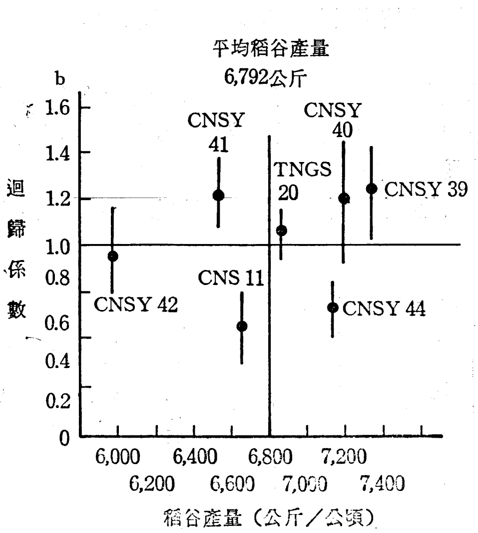


圖3. 香米地方試驗各參試品系之迴歸係數與平均稻谷產量（73 I）

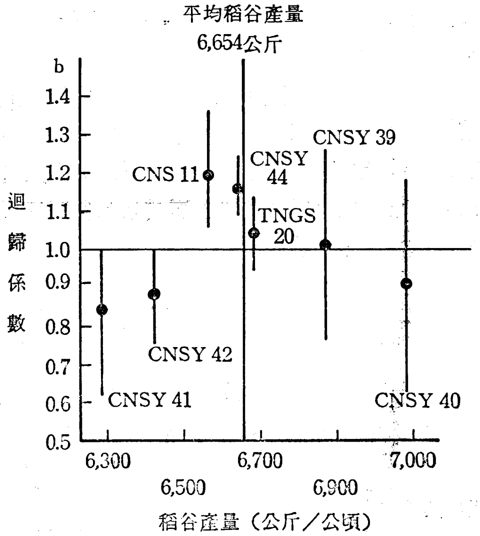


圖4. 香米地方試驗各參試品系之迴歸係數與平均稻谷產量（72 II）

表6. 臺農秈20號秈稻區域試驗

年期	地點	臺農秈20號 全生育日數（日）	株高（公分）	穗數（穗）	稻穀產量 公斤／公頃	%	臺中秈3號（CK） 全生育日數（日）	株高（公分）	穗數（穗）	稻穀產量 公斤／公頃	%
73 I	大村	132	111.6	13.8	6,129	102.7	136	89.7	14.5	5,968	100
	嘉義	139	112.3	12.3	5,539	81.6	139	93.0	15.2	6,789	100
	屏東	116	93.6	10.6	6,144	104.7	116	88.0	11.8	5,867	100
	平均	129	105.8	12.2	5,938	95.7	130	90.2	13.8	6,208	100
74 I	大村	116	111.2	10.8	5,819	80.4	121	111.8	12.1	7,241	100
	嘉義	138	109.9	12.5	6,067	80.7	139	94.4	17.0	7,522	100
	屏東	143	90.1	11.6	6,666	81.6	126	78.5	18.1	8,166	100
	平均	132	103.7	11.6	6,184	80.9	129	94.9	15.7	7,643	100
73 II	大村	103	99.7	14.0	5,219	142.2	110	83.9	20.6	3,671	100
	嘉義	106	104.7	15.2	5,494	103.5	106	88.5	16.2	5,311	100
	屏東	108	105.5	12.9	5,439	130.7	108	103.0	13.6	4,161	100
	平均	106	103.3	14.0	5,502	125.6	108	91.8	16.8	4,381	100
74 II	大村	107	100.5	12.8	5,200	129.3	105	78.9	14.8	4,022	100
	嘉義	106	111.0	12.0	5,855	103.3	110	92.1	14.4	5,667	100
	屏東	121	102.1	12.9	4,666	107.7	121	78.4	13.1	4,333	100
	平均	111	104.5	12.6	5,240	112.1	112	83.1	14.1	4,674	100

30.7%及7.7%，嘉義3.5%及3.3%，由此可知臺農秈20號較適應中南部地區二期作栽培。

二、白米品質

由臺中區農業改良場採用73年一、二期作區域試驗之材料進行米質分析，本品種及對照品種之分析結果如表七，白米率及完整米率均較對照品種臺中秈3號高，蛋白質則較低，其他項目與對照品種臺中秈3號差異不大，米飯食用品質由臺中區農業改良場74年一期作檢定結果如表八。臺農秈20號爲秈稻，採用對照品種爲蓬萊稻良質米品種臺農68號，因此在粘彈性，光澤方面較臺農68號略差，但香味、口味、色澤都較佳。

表7. 臺農秈20號之白米品質調查表（臺中區農業改良場檢定）

品種（系）名稱 \ 項目	期作	白米率(%)	完整白米率(%)	長度	長／寬	透明度	心白	腹白	膠化溫度	膠體軟硬度	顆粒性澱粉(%)	粗蛋白(%)
臺農秈20號	73 I	70.1	58.5	MS/M	I	3	0	0	I	L	18.5	8.76
	73 II	—	—	MS/M	I/S	3	1	0	L	M	18.9	7.71
臺中秈3號（CK）	73 I	63.9	30.3	ML/L	S	2	0	1	I	L	17.8	9.45

表8. 臺農秈20號之米飯食用品質（74年臺中區農業改良場檢定）

品系名稱 \ 項目	風味（30%）		外觀（30%）		粘彈性（40%）		合計
	香味	口味	光澤	色澤	粘性	彈性	
臺農秈20號	4.8	0.3	−2.7	0.3	−1.6	−2.0	−0.9

註：以臺農68號爲對照品種

三、耐寒性檢定

耐寒性檢定由桃園區農業改良場辦理，本品種參加72年二期作及73年一期作之檢定，結果如表九，秈稻多半對於低溫較爲敏感，臺農秈20號在本項檢定結果屬於感或極感級，顯示本品種亦如其他秈稻品種，耐寒性較差，栽培時應注意避免寒害。

表9. 臺農秈20號之耐寒性（桃園區農業改良場檢定）

品種（系）名稱 \ 年期 \ 調查時期	七十二年二期				七十三年一期	
	抽穗期		成熟期		秧苗中期	
	級數	反應	級數	反應	級數	反應
臺農秈20號	9	HS	9	HS	7	S

四、臺農秈20號對各種病蟲害之抵抗性

1.稻熱病抵抗性

依據73、74年全省統一病圃由嘉義分所及臺東區農業改良場負責檢定稻熱病，檢定結果如表十，本項檢定分爲水田式及旱田式病圃二種，水田式病圃爲一般栽植方式而施用重肥促其發病。葉稻熱病反應因地區及年度稍有差異即葉稻熱病在臺東區74年第一期作爲中抗、穗稻熱病在嘉義病圃爲抗，臺東則爲中抗，旱田式病圃由嘉義分所辦理，播種於旱田式病圃早晚在葉面上噴水造成高溫多濕之環境

，促使葉稻熱病發生，由旱田式病圃檢定結果顯示一、二期葉稻熱病都屬抗級。

表10. 臺農秈20號對稻熱病抵抗性（嘉義分所及臺東區農業改良場）

年度	品種（系）名稱	水田式病圃（一期） 葉稻熱病 嘉義	葉稻熱病 臺東	葉稻熱病 平均	穗稻熱病 嘉義	穗稻熱病 臺東	穗稻熱病 平均	旱田式病圃 葉稻熱病 嘉義 一期	嘉義 二期
73	臺農秈20號	R	R	R	HR	MR	R	R	R
	臺農秈14號（CK）	R	R	R	HR	MR	MR	R	R
74	臺農秈20號	R	MR	MR	R	MR	MR	R	R
	臺農秈14號（CK）	R	R	R	HR	R	R	R	R

2.白葉枯病抵抗性檢定

全省統一病圃之白葉枯病檢定，由臺中區農業改良場檢定，本品種於73年及74年配合區域試驗辦理，結果如表11，73年一、二期作爲中抗級，但在74年則爲中感至極感。

表11. 臺農秈20號對白葉枯病抵抗性（臺中區農業改良場）

品種（系）名稱	七十三年一期	七十三年二期	七十四年一期	七十四年二期
臺農秈20號	MR	MR	MS	HS
臺農秈14號（CK）	MR	MR	MS	MS

3.紋枯病抵抗性檢定

本品種於73年及74年參加由臺南區農業改良場負責檢定之全省統一病圃—紋枯病檢定，本項檢定分爲接種區及不接種區，結果如表12，由二者結果看來屬於中感～感。

表12. 臺農秈20號對紋枯病抵抗性（臺南區農業改良場）

品種（系）名稱	七十三年一期 接種區	七十三年一期 不接種區	七十三年二期 接種區	七十三年二期 不接種區	七十四年一期 接種區	七十四年一期 不接種區	七十四年二期 接種區	七十四年二期 不接種區
臺農秈20號	MS	MR	MS	MS	S	MS	MS	S
臺農秈14號（CK）	MS	S	MR	MR	S	MS	HS	S

4.褐飛蝨抵抗性檢定

褐飛蝨抵抗性檢定配合區域試驗材料在民國73年一期及74年一期由嘉義農業試驗分所植保系檢定結果如表13，由二次結果顯示臺農秈20號對褐飛蝨反應皆爲抗級，顯示本品種對褐飛蝨具有抗性。

表13. 臺農秈20號對褐飛蝨抵抗性（嘉義分所植保系）

品種（系）名稱	七十三年一期	七十四年一期
臺農秈20號	R	R
臺農秈14號（CK）	R	R

五、臺農秈20號之優劣點

（一）臺農秈20號之優點：

1.稻米具有濃芳之香味，爲本省第一個經雜交選育成功的香米新品種。

2.粒型爲中長稍細，外表富有光澤，腹心白率少、米質優良，商品價値高，外觀甚佳，直鏈性澱粉含量低，約18～20%。具有類似稉稻軟性膠體特性，風味與食味均佳。

3.具有多種之病蟲害抗性如對葉稻熱病及穗稻熱病爲中抗，對白葉枯病爲中抗，對褐飛蝨屬抗級，適應於本省病蟲害易發生之中南部地區栽培，較具有高產量及穩定性。

4.由區域試驗結果顯示，稻穀產量二期作二年平均超過對照品種臺中秈3號17.4%。

（二）臺農秈20號之缺點：

1.耐寒性較差，一期作育苗時應注意保溫，插秧期不宜過早（以嘉南地區爲例，宜在2月下旬以後），二期作爲避免後期低溫影響稔實，不宜種植過遲（宜在7月底前插秧完畢）。

2.脫粒性較易，因此不宜過熟收穫，以免機械收穫時造成脫粒損失。

3.對紋枯病不具抗性應注意防治，生育日數與臺中秈3號類似屬中晚熟品種，穗數較少，應注意栽培管理提高產量潛力。

六、臺農秈20號之栽培要點：

1.適期插秧：本品種耐寒性較差，在第一期作之插秧不宜過早，以防苗期及本田早期遭受寒害，二期作之插秧則不宜過遲，以防成熟期受到低溫之影響，以中南部而言，第一期作之插秧宜在二月下旬以後，第二期作之插秧宜在7月下旬最遲不要超過8月上旬，應配合當地氣候與農時，適時播種及插秧。

2.育苗時宜疏播：本品種種子較細如果播種過多時，所育成之秧苗細小軟弱，本田之生育易受影響，植株柔弱。要育成短矮粗壯之苗，必須疏播，每個育苗箱播種量以150公克爲佳。

3.栽培密度：宜採寬行密植，即行距27公分，株距13.5公分，每坪株數在90株左右或依一般插秧機之行株距插秧。

4.施肥量：本品種需肥量較多，在重肥之下更能發揮高產潛力，每公頃肥料用量爲硫酸錏 600～700公斤，過磷酸石灰300公斤，氯化鉀200公斤，並視土壤肥力氣候或實際生育情形適量增減。

5.早期施肥：爲確保有效分蘖，除基肥外追肥應儘早施用以促進早期分蘖，一期作第一次追肥在插秧後15～20天，第二次追肥在25～30天，二期作第一次施肥在插秧後10～15天，第二次在20～25天，以確保早期有效分蘖。

6.穗肥：穗肥通常分爲幼穗形成期及減數分裂時期二次，但穗肥之施用應視當時之生育情形來決定施用量，以每公頃硫酸錏50～100公斤另加20公斤氯化鉀爲宜。

7.適期收穫：臺農秈20號比較容易脫粒，在沿海季節風大的地區不宜栽培，一般地區栽培時，應注意收穫適期，不能過遲，又機械收穫時盡量減速，以減少損失。

七、收穫乾燥貯藏

1.香米之香味爲揮發性，因此宜把握收穫適期不要過遲，同時在乾燥時儘量採用緩慢方式乾燥至水分含量在14～15%爲宜，貯存時切勿放置通風不良之密閉倉庫，應貯放在冷凍通風良好之地方，以免香味揮失。

八、病蟲害防治

1.預防毒素病：本品種至目前爲止，毒素病較少發生，但最好在育苗期當翻開尼龍網時以及本田插秧後10日左右，防治斑飛蝨及黑尾浮塵子，以防傳播毒素病。

2.紋枯病：插秧後30～40天及抽穗前必須注意防治。

3.稻熱病：本品種爲中抗級，因此稻熱病較易發生地區，在插秧後40天左右應注意防治，穗稻熱病在抽穗前及齊穗後必須防治。

4.褐飛蝨：本品種雖具有抗性，如附近地區發生嚴重爲害時，視情形適宜防治。

5.斑飛蝨：本品種對斑飛蝨不具抗性，應在抽穗前及齊穗後必須注意防治。

6.螟蟲：在發生嚴重爲害時，應注意發生時期，適時防治。

7.其他病蟲害請參閱農林廳編列之「植物保護手册」適時防治。

臺農秈20號之育成承蒙農委會之資助及各區農業改良場之協助，謹此誌謝。

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Development of Aromatic Rice Variety Tainung Sen 20[1]

S. C. Yang[2], W. L. Chang[3], C. N. Chao[2], L. C. Chen[3]

Summary

Rice variety Tainung Sen 20 was a selection from the cross between Chianung Shi-pi 671178 and a F_4 line, having heavy aromatic flavor, excellent rice quality and resistance to blast disease and brown planthopper. Its plant height was 109—115cm with panicle number of 12—16 per hill, and the growing duration, 107—143 days. It has long grains somewhat slendel and shinny, with very few white-belly kernel. The average grain yield at 3 locations in 2 years was 6,061 kg/ha and 5,371 kg/ha, respectively in the first and second crops. The yield potential was higher at Kao-ping area in the first crop. It is adaptable in where the brown planthopper prevails.

This variety is less cold tolerance, therefore, it is not recommended for early planting in the first crop. Since this is easy-shatting, it is not recommended to be grown in the coastal region where monsoon is strong and keep this rice in a cool place for storage to maintain the aromatic flavor.

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1. Contribution No. 1428 from the Taiwan Agricultural Research Institute.

2. Agronomist, 3. Formerly department head of agronomy, Chia-yi Agricultural Experiment Station, TARI, Chia-yi, Taiwan.

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優良單交種玉米之親本改良

I. 理想供給親自交系之鑑別[1]

盧　煌　勝[2]

摘要　利用8個玉米自交系親本及其28個 F_1 全互交（不包括反交）單交種所進行之田間試驗資料，估算（$\mu C+\mu F$）－（$\mu D+\mu E$）及 μG 值，以鑑別理想供給親自交系。理想供給親自交系具有與產量有關之顯性基因，而此類基因並不存在於一有待改良之單交種中。當設計 Hi25×CM103 、UH-1×ICAL210 及 Pi77-4257 × Hi28 為有待改良之單交種時，在不完全顯性之前提下，Pi77-4257 及 Oh545 將獲選為 CM103 及 ICAL210 自交系改良之理想供給親。本試驗結果顯示：利用理想供給親進行優良單交種之親本改良，或為玉米育種之另一有利途徑。

近年來，各類作物種源的搜集、保存已廣受作物育種家們的重視，種源利用潛力之評估工作也陸陸續續地在世界各地進行著，為期育種工作之突破，作物育種家們莫不急於在種源中尋獲有價值的材料[11]。關於玉米育種方面，育種計畫之發展及其成功機率之研究，許多數量遺傳原理的建立，確實作了相當大的貢獻[1]。Hallauer and Miranda[9] 對外來玉米種源（exotic maize germplasm）之潛能與利用，以及輪迴選種方法之配合等等均作了很詳細的討論。Gerrish[8] 評估熱帶型及溫帶型種源之適應性，兼論雜種優勢模式之利用，見解頗為獨到。Dudley[2,3,4,5,6] 研究發展基因轉移理論及鑑定理想供給親自交系或族羣（donor lines or populations with favorable alleles not present in P_1 or P_2 of a single cross）之方法，以協助育種家有效地達成單交種之親本改良目的。Gerloff[7] 比較三種估算相對基因座數目之方法，發現 Dudley 之 μG 估值[3]與估算供給親之有利基因數目（此基因並不存在於待改良單交種之親本中），具最大的遺傳相關。

本研究係使用 Lee *et al.*[10] 之全互交試驗資料，依 Dudley[3] 提議之分析方式，探討鑑定理想供給親自交系之方法，及應用其在單交種之親本改良上之可行性，以供作物育種研究之參考。

材料與方法

本試驗使用之材料計有 Hi25、Oh545、UH-1、Pi77-4257、ICAL210、Hi28、CM103、及 CM109 等8個自交系及其部分全互交（不包括反交）之28個 F_1 組合，1984年春作在農試所霧峰農場進行試驗。田間試驗採逢機完全區集設計，四重複，三行區，行長 5m，行株距 80×25cm，公頃株數50,000。肥料施用量為 N：P_2O_5：K_2O＝200：90：60 kg/ha，基肥包括 N 60kg、P_2O_5 及 K_2O 全量，播種後一個月及雄花抽穗前，分別加施 N 70 kg 各一次。其他田間管理，如除草、中耕、培土及灌溉，依一般玉米栽培法進行。成熟期，每小區逢機10株，取穗脫粒，估算子粒重量及含水

1. 臺灣省農業試驗所　研究報告第 1429 號。
2. 本所農藝系副研究員。臺灣省　臺中縣　霧峰鄉。

Table 1. Backgrounds of the eight inbreds evaluated.

Inbred line	Background
Hi25	(B14A×MV source) BC4 (Corn Belt dent)
Oh545	[(M14×CI187-2) Oh45]×[(Oh45A×Oh45T) Oh45] (Corn Belt dent)
UH-1	B68 derivative (Corn Belt dent)
Pi77-4257	Pioneer hybrid derivative (Corn Belt dent)
ICAL210	Cuban flint derivate (Colombia flint)
Hi28	(CM105 (India)×MV source) BC5 (India flint)
CM103	Colombia 1×38-11 (India flint)
CM109	Colombia hybrid derivative (India flint)

率，並換算為 15.5%含水率子粒重。8 個自交系之背景資料列於表 1，其與 28個 F_1 組合之單株子粒產量（g/plant）則列如表 2。

Table 2. Grain yield (g/plant) of inbred lines (on diagonal) and single crosses (above diagonal)+.

Inbred line	Hi25	Oh505	UH-1	Pi77-4257	ICAL210	Hi28	CM103	CM109
Hi25	63	138	126	172	174	187	149	168
Oh545		98	176	158	184	178	167	172
UH-1			73	165	161	164	164	172
Pi77-4257				109	173	182	172	169
ICAL210					116	178	158	151
Hi28						120	158	166
CM103							94	149
CM109								108

+ LSD(0.05)=17；LSD(0.01)=23.

資料依 Dudley[3] 所提議之方法進行分析。本文中將 Hi25×CM103、UH-1×ICAL210 及 Pi77-4257×Hi28 設計為有待改良之 3 個單交種，P_1 及 P_2 分別代表其父母本。8 個自交系除每一個單交組合之二親本外，所餘之 6 個自交系則當成供給親（Pw, donor line），其可能提供有利基因給單交種之親本。理想之 Pw 至少需具備一個以上之有利基因，而此基因並不存在於 P_1 或 P_2。利用理想 Pw 進行 P_1 或 P_2 改良，結果產生之 P_1' 或 P_2'，組成新的單交種 $P_1' \times P_2$ 或 $P_1 \times P_2'$，其產量必然優於原來之雜交組合 $P_1 \times P_2$。理想 Pw 之鑑別乃根據 Pw 中具有利基因之相對基因座數目的多寡（μG）來決定。至於利用理想 Pw 以改良 P_1 或者 P_2，乃由 Pw 與 P_1 及 P_2 之親疏程度作考慮，此種親疏關係以 $(\mu C+\mu F)-(\mu D+\mu E)$ 計算之。μG 及 $(\mu C+\mu F)-(\mu D+\mu E)$ 之計算公式列如表 3。

Table 3. Expectation of two estimators assuming complete dominance.

Equation+
$(\mu C+\mu F)-(\mu D+\mu E)=[2(P_2\times Pw)-2(P_1\times Pw)-P_2+P_1]/2$
$\mu G=[(P_1\times Pw)+(P_2\times Pw)-Pw-P_1-P_2-(P_1\times P_2)]/4$

\+ P_1, P_2 are parental lines, and Pw is donor line.
$\mu C\times\mu F$ is the total relative number of loci for which P_1 and Pw have the same (either + or −) alleles while $\mu D+\mu E$ is the total relative number of loci for which P_2 and Pw have the same alleles.

結果與討論

單株子粒產量所估算之 $(\mu C+\mu F)-(\mu D+\mu E)$ 及 μG 值，依單交組合之不同，分別列於表 4，5，6。在表 4，Hi25(P_1) × CM103(P_2) 設計爲有待改良之單交種，Oh545、UH-1、Pi77-4257、ICAL210、Hi28 及 CM109 分別爲 Pw。$(\mu C+\mu F)-(\mu D+\mu E)$ 值顯示：Oh545 及 UH-1 之 $(\mu C+\mu F)-(\mu D+\mu E)$ 同爲顯著正值，故與 Hi25 (P_1) 關係較爲接近，二者均可能充當改良 Hi25 之理想 Pw；而 Pi77-4257、ICAL210、Hi28 及 CM109 之 $(\mu C+\mu F)-(\mu D+\mu E)$ 同爲顯著負值，故與 CM103(P_2) 關係較爲密切，可能作爲 CM103 之理想 Pw。另外由 μG 值觀之，所有 μG 均呈負值，就此而言，在完全顯性 (complete dominance) 之假設前提下，並無任一個自交系堪稱理想 Pw。不過，所有之 μG 之絕對值均大於 LSD (0.05)，因此推測：對子粒產量之控制，不完全顯性 (incomplete dominance) 或許比完全顯性更爲重要。在不完全顯性之假設前提下，比較 μG 之相對大小，則 Pi77-4257 之 μG (−17.8) 最大，故可作爲 CM103 之理想 Pw。

Table 4. Estimates of relative numbers of loci for grain yield per plant when Hi25×CM103 is $P_1\times P_2$.

Pw	$(\mu C+\mu F)-(\mu D+\mu E)$	μG
Oh545	13.5*	− 24.8
UH-1	22.5*	− 22.3
Pi77-4257	− 15.5*	− 17.8
ICAL210	− 31.5*	− 22.5
Hi28	− 44.5*	− 20.3
CM109	− 34.5*	− 24.3
LSD (0.05)		2.4

* Significantly diffferent from 0 at $\alpha=0.05$.

UH-1(P_1)×ICAL210(P_2) 組合（表 5），Hi25、Oh545、Pi77-4257、Hi28、CM103及 CM109 爲 Pw。其中與 UH-1 關係最爲相近之自交系爲 Hi25；與 ICAL210 關係密切的自交系包括 Oh545、Pi77-4257、CM103 及 CM109。考慮 μG 之相對值，在不完全顯性之假設前提下

Table 5. Estimates of relative numbers of loci for grain yield per plant when UH-1×ICAL210 is $P_1 \times P_2$.

Pw	(μC+μF)−(μD+μE)	μG
Hi25	26.5*	− 28.3
Oh545	− 13.5*	− 22.0
Pi77-4257	− 13.5*	− 30.3
Hi28	− 7.5	− 32.0
CM103	− 27.5*	− 30.5
CM109	− 42.5*	− 33.8
LSD (0.05)		2.4

* Significantly different from 0 at α=0.05.

，Oh545 (μG=−22.0) 應為 ICAL210 之理想 Pw。表 6 之 Pi77-4257(P_1)×Hi28(P_2) 組合，6 個測試之 Pw 中，僅 Oh545 及 CM103 分別與 Pi77-4257 及 Hi 28 關係至為密切，但由 μG 值觀之， Oh545 為-43.3 ，CM103 為-43.8 ，均顯著小於 Hi25 之-28.8 及 UH-1 之 -38.8，故二者均無法作為理想 Pw。

Table 6. Estimates of relative numbers of loci for grain yield per plant when Pi77-4257×Hi28 is $P_1 \times P_2$.

Pw	(μC+μF)−(μD+μE)	μG
Hi25	9.5	− 28.8
Oh545	14.5*	− 43.3
UH-1	− 6.5	− 38.8
ICAL210	− 0.5	− 44.0
CM103	− 19.5*	− 43.8
CM019	− 8.5	− 46.0
LSD (0.05)		2.4

* Significantly different from 0 at α=0.05.

綜合以上三個單交種之分析結果，發現不完全顯性對玉米單株子粒產量之高低或許有某種程度的控制。Pw 與 P_1 及 P_2 之親疏關係，係根據相對基因座數目比較而得，大體而言，四個硬粒種 (flint) 自交系作為 Pw 時，與單交種之硬粒種親本之密切關係相當一致；而四個馬齒種 (dent) 自交系作為 Pw 時，與單交種之馬齒種親本之密切關係則隨單交組合之不同而有所變動。如在 Hi25×CM103 組合中（表 4），馬齒種之 Pi77-4257 反而與硬粒種之 Hi 25 關係較為密切；在 UH-1×ICAL210 組合中（表 5），馬齒種之 Oh545 及 Pi77-4257 亦與硬粒種之 ICAL210 有較密切的關係。由是觀之，在玉米種源中，欲維持馬齒種×硬粒種之雜種優勢模式 (heterosis pattern)，

所選用之馬齒種及硬粒種材料，均需經過測試，而不能僅憑粒型加以劃分利用。此與 Gerrish[8] 探討熱帶型×溫帶型雜種優勢之現象，有相類似之結論。

在育種工作上，運用理想 Pw 進行優良單交種之親本改良（P_1 或 P_2），將是十分實用有效的[3]。就本文中之 UH-1(P_1)×ICAL210(P_2) 爲例，經比較 (μC+μF)−(μD+μE) 及 μG 值結果，Oh545 爲 ICAL210 之理想 Pw。改良 ICAL210 的第一步，即將 ICAL210 與 Oh545 雜交，產生 (ICAL210×Oh545) F_1，而後種植 F_1 植株，令其自交產生 F_2 種子，並在 F_2 分離世代開始選拔及繼續自交分離。由於 ICAL210（硬粒種）及 Oh545（馬齒種）在粒型上及單株產量上有較大的差異 (116：98g/plant, LSD (0.05)=17), F_1 自交分離前，可考慮先回交至 ICAL210 一次以上，如此將能提高在分離世代中選獲優良個體之機率[2]。

臺灣目前推廣之玉米品種，如臺農 1 號、臺農 351號及臺南 17號，其單位面積產量均已較舊有品種高出甚多。未來爲求產量的繼續突破，我們必須充分利用更多的自交系及族羣種源，藉此或可選育出兩個優秀自交系，組成更高產單交種完全取代現有品種；或選育出一個組合力甚高的自交系取代原有單交種之一個親本；亦可以考慮審愼評估自交系及族羣種源，鑑別出理想 Pw，以作爲優良單交種之親本改良來源[3,4,5,6]。當決定經由鑑別理想 Pw 自交系以改良單交種之親本時，假設欲改良之單交種是臺農 1 號（TA2808-176×TA3651-377），而可資利用的自交系一共有 20 個，首先只需將此20個自交系（Pw）分別與 TA2808-176 及 TA3651-377 雜交。次一期作進行產量比較試驗，材料包括：20個 Pw×TA2808-176，20個 Pw×TA3651-377、TA2808-176×TA3651-377、20個Pw、TA2808-176 及 TA3651-377，合計63個參試（41個單交種及22個自交系）。此一期作，也可同時生產所有 F_1 組合之 F_2 種子。根據 (μC+μF)-(μD+μE) 及 μG 資料，即可鑑別何者爲理想 Pw。次一期作僅挑出有希望之 F_2 族羣（理想 Pw×TA2807-176 或理想 Pw×TA3651-377 之F_2）繼續選拔與自交分離。依循這種方式，當能有效地改良 TA2807-176 或 TA3651-377，增進雜種優勢，而達到提高單位面積產量之目標。此種利用理想供給親自交系進行優良單交種之親本改良方法，或爲玉米育種之另一有利途徑。

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Improvement of Parents of Elite Single Crosses in Maize

I. Identification of inbred lines with favorable alleles[1]

H. S. Lu[2]

Summary

Data from field evaluation of eight parental maize inbred lines and 28 F_1 diallel hybrids were used for estimation of $(\mu C+\mu F)-(\mu D+\mu C)$ and μG for identifying inbred lines containing dominant allele affecting grain yield, which are not already present in an elite cross. When Hi25×CM103, UH-1×ICAL210 and Pi77-4257×Hi28 were designated as the elite hybrids to be improved, if incomplete dominance is assumed, Pi77-4257 and Oh545 would be chosen to improve CM103 and ICAL210, respectively. Results of this study suggest the method may be useful in practical breeding programs.

1. Contribution No. 1429 from Taiwan Agricultural Research Institute.
2. Corn Breeder, Department of Agronomy, Taiwan Agricultural Research Institute, Wufeng, Taichugn, Taiwan 41301, ROC.

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Response of Two Maize Populations to Reciprocal Recurrent Selection in a High-yield Environment[1]

H. S. Lu[2] and R. J. Lambert[3]

Abstract: A selection program using reciprocal recurrent selection procedures in maize (*Zea mays* L.) was developed. Intra-and interpopulation selection procedures were used for two maize populations BS10 and RSSSC. Intrapopulation selection procedures included phenotypic mass selection for multiple leaf and multiple stalk-rot disease resistance and S_1 family selection for grain yield in a high-yield environment. Interpopulation improvement involved selection of testcrosses of S_1 family×inbred tester in a high-yield environment. Evaluations of populations *per se*, population crosses and populations×testers for response to three cycles of selection for grain yield were conducted at four environments. Evaluation of populations *per se* and population crosses for response to three cycles of selection for multiple leaf disease and multiple stalk-rot resistance was conducted at disease nursery in 1985. The results indicate that selection response was consistent among environments. Gain from selection was satisfactory in populations *per se*, population crosses and populations×testers for grain yield, multiple leaf disease resistance and multiple stalk-rot resistance. Linear response to three cycles of selection for grain yield for BS10, RSSSC, BS10×RSSSC, BS10×B37, and RSSSC×B79 were: 0.95, 0.69, 0.65, 0.65 and 0.24 Mg/ha/cycle, respectively. The rates of gain for grain yield obtained in the present study compare favorably with published reports. Linear response for stalk lodging for BS10, BS10×RSSSC and BS10×B37 were: −9.0, −5.4 and −3.5%/cycle, respectively. All populations *per se*, population crosses and populations×testers showed significant increase in penetrometer reading. Increase in plant height and ear height were observed for RSSSC, BS10×RSSSC and RSSSC ×B79. Population BS10 showed an increase in 300-kernel weight and kernel number per ear, and a decrease in ear number per 100 plants. Population RSSSC only showed an increase in 300-kernel weight. Three cycles of selection slightly increased grain moisture in BS10 and BS10×B37. This result indicates the procedures of selection in a high-yield environment are beneficial in improving grain yield, multiple disease resistance and stalk lodging resistance in maize populations *per se* and their hybrids.

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1. Contribution No. 1430 from the Taiwan Agricultural Research Institute, Taiwan, Republic of China.

2. Corn Breeder, Department of Agronomy, Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan 41301, ROC.

3. Professor of plant genetics, Department of Agronomy, University of Illinois, 1102S. Goodwin Ave., Urbana, IL61801.

INTRODUCTION

Stalk lodging accounts for a large part of annual yield losses in corn. Stalk-rots caused by *Diplodie maydis* (Berk.) Sacc., *Gibberella zeae* (Schw.) Petch., *Fusarium moniliforme* Sheld. and *Collectrichum graminicola* (Ces.) Wils. are a major component of stalk lodging. In population improvement work, various recurrent selection procedures were effective for stalk-rot resistance. [13,20,23,24,30]

Maize leaf blights caused by *Exserohilum turcicum* (Pass.) Leonard & Suggs, *Bopolaris maydis* (Nisik.) Shoemaker and *Colletrichum graminicola* (Ces.) Wils. not only affected grain yield but allowed for predisposition to stalk-rot [5]. Jenkins *et al.* [12] found that recurrent selection was an effective breeding method for concentrating genes for resistance to *Exserohilum turcicum.* Compared to half-sib and S_1 family selection for resistance to northern corn leaf blight, Diplodia stalk-rot, and anthracnose leaf blight and stalk-rot, Miles *et al.* [23,24] found mass selection would be the most efficient method of improving resistance to these diseases in corn populations.

In addition to direct response, correlated changes in other agronomic traits usually accompany population improvement. Correlated changes varied for different selection methods, objectives and materials. Selection for high grain yield is usually accompanied with an increase in ear number per plant [19,25,26], plant height [19], ear height and grain moisture [6,19]. No change in ear height or grain maturity was reported by Eberhart *et al* [4]. However, a decrease in ear height has been reported by Moll and Stuber [25] and Moll *et al* [26].

Martin and Russell [20,21] reported three cycles of recurrent selection for stalk-rot resistance in BS1 population caused a significant decrease in grain yield, plant height and field stalk lodging. Jinahyon and Russell [13,15] showed selection for stalk-rot resistance in a Lancaster open-pollinated population significantly increased plant height, ear height, stalk lodging resistance and grain moisture, but did not change in grain yield. Miles *et al.* [23] reported mass selection for resistance to four diseases (northern leaf blight, Diplodia stalk-rot, and anthracnose leaf blight and stalk-rot) would be very effective in improving disease resistance in corn populations and that such improvement would not affect yield potential of the populations if adequate effective population size is maintained.

Thompson [33] suggested rind penetrometer measurements as a non-destructive method for improving stalk strength in the field. Penetrometer readings were negatively correlated with stalk-rot rating [20,34,37], and leaf blight infection [37]. Rind penetrometer measurements were highly correlated with total stalk lodging resistance [20,33,34]. Stalk lodging has been reduced by using recurrent selection to reduce plant and ear heigh [1,15].

The primary objectives of this research were: (1) to evaluate direct response to selection for grain yield, multiple leaf disease resistance and multiple stalk-rot resistance; and (2) to evaluate concomitant changes in field stalk lodging and other agronomic traits.

MATERIALS AND METHODS

Experimental Material

Two synthetic cultivars were used in this study: RSSSC, a version of Stiff Stalk Synthetic as described by Kauffmann and Dudley[16] and Iowa Two-Ear Sythetic (BS10) described by Hallauer[8]. Cycle-4 of BS10 from Hallauer's reciprocal full-sib selection program was used as the base population in this study. Based on the data from diallel crosses of eight synthetics and other considerations BS10 and RSSSC were selected to initiate a reciprocal recurrent selection in a high-yield environment (HYE). The general combining ability effects of BS10 and RSSSC were high for grain yield and stalk lodging[17,18].

Experimental Management Practice

The experiments were conducted in four environments: HYE1, HYE2, UNE1 and UNE2. The HYE1 was located at the Agronomy-Plant Pathology Farm of the University of Illinois at Urbana, Illinois. The soil type of this field is a Flanagan fine silty-loam (montmorillonitic mesic Aquic Argiudolls). A crop rotation of maize and soybean (*Glycine max* (L.) Merrill) is used each year. Maize was planted on 23 April, 1985 and grown in a plot with two 4.6m rows and plant density of 81,785 plants/ha. A preplant application of herbicide was used with no row cultivation during the growing season. The fall application of fertilizer has included 336 kg/ha of potassium (K_2O) and phosphorus (P_2O_5). Prior to planting 250kg/ha of nitrogen (anhydrous ammonia) was applied to the soil. An additional 250kg/ha of nitrogen was applied in the irrigation water when the plants were 1m tall. Supplemental irrigation water was applied based on soil tensionmeter reading at the 46.3cm level during the critical period of 10 days prior to anthesis to about 45 days into grain-fill. The HYE2 was located at the Herman Warsaw's farm, Saybrook, Illinois. The soil type of this field is a Saybrook fine silty-loam (mesic Typic Argiudolls). Maize was grown in a plot with two 5.8m rows and plant density of 83,708 plants/ha. Maize was planted on 29 April, 1985. The fall application of fertilizer has included 280kg/ha of phosphorus and potassium. Prior to planting 280kg/ha of nitrogen was applied to the soil and an additional 280kg/ha of nitrogen was sidedressed when plants were 1m tall. The UNE1 was located at the Agronomy-Plant Pathology Farm of University of Illinois at Urbana, Illinois. The soil type of this field is a Drummer fine silty clay-loam (mesic Typic Haplaquolls). Maize was planted on 26 April, 1985 and grown in plots consisting of a single 5.3m row with plant density of 61,508 plants/ha. Fertilizer applications consisted of 241kg/ha of nitrogen at planting and a fall application of 207kg/ha of phosphorus and potassium. The UNE2 was located at the Agronomy-Plant Pathology Farm of University of Illinois at Urban, Illinois. The soil type of this field is a Flanagan fine silty-loam (montmorillonitic mesic Aquic Argiudolls). Maize was planted on 7 May, 1985. The row length, row spacing, plant density and fertilizer application in UNE2 were the same as in UNE1.

All yield trials were machine-planted. All plots were overplanted and thinned to a perfect stand. Prior to harvest, the number of stalk lodged plants (plants broken below

the ear-node) in each plot were determined. Using these data percent stalk lodging was calculated for all plots. The HYE1 was hand-harvested while HYE2, UNE1 and UNE2 were machine-harvested. Individual plot grain weight and grain moisture was determined and the grain yield calculated as megagrams per hectare (Mg/ha) at 15.5% moisture level.

Plant height, ear height and penetromter measurements were determined only for the HYE1 and UNE1 experiments. Plant height and ear height were measured after anthesis, on five plants per plot by measuring the distance (cm) from the soil surface to the flag leaf collar and soil surface to the ear-bearing node, respectively. Approximately three weeks after anthesis, rind puncture measurements (Kg) were taken on five plants in a plot using a commercially available (Chatillon) hand-held penetrometer. Penetrometer measurements were taken in the center of the second elongated internode above ground. The means of these measurements were calculated for each plot. The total number of ears (ears with more than 50% seed set) were counted and divided by the number of plants harvested in each plot to calculate ear number per 100-plants.

In HYE1 a 250g grain sample was saved from each plot. The total kernel number in each 250g sample was counted and weight per kernel (g) was calculated. The kernel number per ear was obtained by: (Grain yield per plot (g)/Weight per kernel (g)/Number of ears per plot. The 300-kernel weight (g) at 15.5% moisture content was obtained by: (300 × Weight per kernel) × (1 - Moisture content)/.845.

Evaluation of progress for multiple disease resistance was conducted in disease nursery. Single-row plots 3.8×0.76m were overplanted and thinned to 9 plants/plot (30, 999 plants/ha). All plants were inoculated twice (June 12th and June 30th), by dropping into the whorl ground leaf tissue collected the previous fall from plants heavily infected with multiple leaf disease (*Exserochilum turcicum*, *Bipolaris maydis*, and *Colletotrichum gramincola*). In each plot 5 plants were inoculated with a mixture of stalk rotting organisms (*Diplodia maydis*, *Gibberella zeae*, *Fusarium moniliforme*, and *Colletotrichum graminicola*) by injecting a conidiae suspecsion (1×10^5 conidiae/ml) into the first elongated internode above the soil approximately 2 weeks after silking. After flowering, the multiple leaf disease reaction was rated (in % leaf area infected on a plot basis) 3 times with 2 week intervals between ratings. At physiological maturity multiple stalk-rot inoculated plants were cut off below the ear and split longitudinally to ground level. Multiple stalk-rot reaction was recorded on a 1 to 9 scale: 1=no spread or less than 50% of discolored tissue in the inoculated internode; 2=more than 50% of discolored tissue in the inoculated internode; 3=discolored tissue reaches lower half of 2nd internode; 4=discolored tissue reaches upper half of the 2nd internode; 5=discolored tissue reaches lower half of the 3rd internode; 6=discolored tissue reaches upper half of the 3rd internode; 7=discolored tissue reaches lower half of the 4th internode; 8=discolored tissue reaches upper half of the 4th internode; 9=discolored tissue reaches the 5th internode or plant prematurely killed.

Field Design And Statistical Analysis

A split plot experiment with the main plots arranged in a randomized complete block

design with four replicates was used for all experiments in this study. Populations, population cross and populations×testers were main plots and cycles of selection were subplots. The analyses of variance was used for all traits, using plot mean data in each experiment. The total sum of squares were partitioned into components for blocks, populations, error a, cycles, populations×cycles and error b. Combined analyses for environments were calculated using methods suggested by McIntosh [22]. In the combined analyses for environments, the total sums of squares were paritioned into environments , blocks/environments, populations, environments×populations, error a, cycles, environments×cycles, populations×cycles, environments×populations×cycles, and error b. F-tests, populations and cycles were considered fixed, and environments random. All components of the analyses of variance were tested against their appropriate error term or interactions.

For each analysis of variance above, regression analysis was used within each population. The total sum of squares for cycles were partitioned into sum of squares for linear, quadratic and cubic regression. Since linear regression explained most of the variability among cycles of selection, only linear regression coefficients are pressented and used to measure rate of change per cycle. Standard errors were calculated for the regression coefficients using the method described by Steel and Torrie [31]. In comparing estimates of linear regression coefficients, the values with confidence intervals that do not overlap are considered to be significantly different from each other at the 5% level of probability.

RESULTS AND DISCUSSION

The two populations used in this study had similar grain yield potential but RSSSC had better stalk quality than BS10. The four environments represented highly productive Illinois corn growing environments. The HYE1 represented a very good management level for corn, with very high fertility, irrigation and high plant density. Grain yiled in HYE1 was very high and consistent. The HYE2 represented a corn field with very heigh fertility and high plant density. Stalk lodging usually caused some grain yield reduction in HYE2. The UNE1 represented a corn field with high fertility and normal plant density. Grain yield in UNE1 was higher than average over the normal environments. The UNE2 represented a corn environment with normal fertility and normal plant density. However, none of the linear regression coefficients within population among envinonments was significantly different from each other.

The combined data showed 0.95, 0.69, 0.65, 0.65 and 0.24 Mg/ha/cycle significant increases of grain yield over 3 cycles for BS10, RSSSC, BS10×RSSSC, BS10×B37 and RSSSC×B79, respectively (Table 1). The smaller grain yield response observed in RSSSC ×B79 in this study was not expected. Since selection cycle means among C_0-C_3 were similar for RSSSC×B79, it is suspected that inbred tester B79 may have some masking effect on the RSSSC×B79 progenies performance. Similar masking effect of inbred tester on testcross progenies performance has been reported by Walejko and Russell [36]. They used B73 as inbred tester and crossed with Lancaster C_0 and C_5 and with Kolk-

Table 1. Means and linear regression coefficients (b_l) for grain yield and stalk lodging of BS10 and RSSSC populations, improved by three cycles of reciprocal recurrent selection in a high-yield environment, and evaluated at two environments, Illinois, 1985.

Population	Grain yield (Mg ha^{-1})	Stalk lodging (%)
BS10-C_0	8.22	46.2
BS10-C_1	9.21	36.3
BS10-C_2	10.25	24.3
BS10-C_3	11.06	20.3
b_l^+	0.95± 0.11	−9.0± 0.71
RSSSC-C_0	9.00	28.9
RSSSC-C_1	9.78	24.5
RSSSC-C_2	10.42	26.3
RSSSC-C_3	11.08	28.7
b_l	0.69± 0.11	0.1± 0.71
BS10-C_0×RSSSC-C_0	9.94	34.6
BS10-C_1×RSSSC-C_1	10.98	28.0
BS10-C_2×RSSSC-C_2	11.37	23.6
BS10-C_3×RSSSC-C_3	11.97	18.2
b_l	0.65± 0.11	−5.4± 0.71
BS10-C_0×B37	10.45	14.0
BS10-C_1×B37	11.80	11.5
BS10-C_2×B37	11.83	6.6
BS10-C_3×B37	12.61	4.0
b_l	0.65± 0.11	−3.5± 0.71
RSSSC-C_0×79	11.37	18.9
RSSSC-C_1×79	11.51	19.1
RSSSC-C_2×79	11.11	20.0
RSSSC-C_3×79	12.30	19.5
b_l	0.24± 0.11	−0.3± 0.71

$_+b_l$ values greater than twice standard error are considered significantly different from zero.

meier C_0 and C_5. In both cases no significant differences between C_0 and C_5 testcrosses could be detected. They concluded B73 has a relatively high frequency of favorable, dominant alleles that 'masked' the effects of the less favorable, recessive alleles in the two populations. However, gene frequencies in heterogeneous population may vary from 0 to 1.0 and include multiple alleles at many loci. Theoretically, the tester parent should contribute 50% of the genes to the testcrosses. In addition, to this dilution effect, genes from the tester may be dominant, epistatic, or complementary, with genes

from the S_1 genotypes to be evaluated. If genetic interactions occur, differences in phenotypic performances of the testcrosses may not be easy to distiuguish. The less accurately genotypes are evaluated, the more random selection becomes.

Plants grown under high plant densites (HYE1 and HYE2) usually have more stalk lodging than plants grown in normal plant densities (UNE1, UNE 2). Comparing between HYE1 and HYE2, and between UNE1 and UNE2 indicated stalk lodging resistance can be improved by selection in a HYE. Combined data from three cycles of selection indicates significant response for stalk lodging were observed in BS10 ($b_1 = -9.0\%$), BS10×RSSSC ($b_1 = -5.4\%$) and BS10×B37 ($b_1 = -3.5\%$). RSSSC and RSSSC×B79 showed nonsignificant response to selection in all four environments.

Goulas and Lonnquist[7] suggested that the HS-S_1 evaluation may lead to selections with better buffering against environment changes. In this study for both grain yield and stalk lodging the responses were similar among environment, supporting this concept. Most studies reported a positive relationship between grain yield and stalk lodging[32,34,35]. However, no significant relationship between grain yield and stalk lodging have also been reported[28]. Our data indicate a simultaneous improvement of grain yield and stalk lodging resistance in BS10 population *per se* and population crosses. This agrees well with results of Colbert *et al.*[2] and Eberhart *et al*[4].

Plants grown in higher plant density (HYE1) usually had higher plant height and ear height. In this study HYE1 and UNE1 had similar plant height and ear height. The trends of the mean values over cycles for plant height were similar to the trends for ear height (Table 2). The selection responese for HYE1 and UNE1 were about the same. Combined data showed that RSSSC, BS10×RSSSC and RSSSC×B79 significantly increased in plant height of 9.2, 3.8 and 3.2cm/cycle, and signficantly increased in ear height of 7.0, 4.1 and 5.1 cm/cycle, respectively. Nonsignificant changes of plant height and ear height to selection for BS10 and BS10×B37 were observed (Table 2). Penetrometer reading was slightly higher for RSSSC than BS10. After three cycles of selection all populations showed a significant increase in rind penetrometer reading. Combined data showed that significant gains per cycle were 0.30, 0.47, 0.36, 0.33 and 0.16 kg for BS10, RSSSC, BS10×RSSSC, BS10×B37 and RSSSC×B79, respectively.

Compared to population BS10, population RSSSC had relatively less progress in stalk lodging. Population RSSSC had better stalk quality in the original population than BS10 . The increase in plant height and ear height in advanced cycles of RSSSC may have caused the lack of a decrease in stalk lodging. However, for a more rapid improvement in reduction of stalk lodging of RSSSC selection for reducing plant height and ear height or using penetrometer reading as supplemental methods when under taking a population improvement program for grain yield and multiple disease resistance may be useful.

Three cycles of selection resulted in a significant change in ear number/100-plants in BS10 ($b_1 = -5.9$) and RSSSC×B79 ($b_1 = 2.4$). The two populations showed a significant increase in 300-kernel weight, BS10 and RSSSC had a 4.3 and 4.8 g/cycle significant increase, respectively. Population crosses and populations×testers showed nonsignificant

Table 2. Means and linear regression coefficients (b_1) for plant height, ear height and penetrometer reading of BS10 and RSSSC populations improved by three cycles of reciprocal recurrent selection in a high-yield environment, and measured at two environments, Illinois, 1985.

Population	Plant height (cm)	Ear height (cm)	Penetrometer reading (kg)
BS10-C_0	234.9	128.5	7.31
BS10-C_1	235.1	132.6	7.46
BS10-C_2	239.0	130.5	7.76
BS10-C_3	238.9	129.7	8.21
b_1^+	1.6± 0.94	0.2± 1.33	0.30± 0.07
RSSSC-C_0	235.6	122.6	7.09
RSSSC-C_1	246.9	127.9	7.85
RSSSC-C_2	248.6	134.0	7.96
RSSSC-C_3	265.6	144.0	8.61
b_1	9.2± 0.94	7.0± 1.33	0.47± 0.07
BS10-C_0×RSSSC-C_0	235.2	124.9	7.17
BS10-C_1×RSSSC-C_1	240.3	126.6	7.76
BS10-C_2×RSSSC-C_2	243.8	127.7	7.88
BS10-C_3×RSSSC-C_3	246.8	138.3	8.34
b_1	3.8± 0.94	4.1± 1.33	0.36± 0.07
BS10-C_0×B37	240.2	127.5	7.63
BS10-C_1×B37	236.7	124.0	7.77
BS10-C_2×B37	241.3	126.8	8.15
BS10-C_3×B37	241.9	123.4	8.61
b_1	1.0± 0.94	−0.9± 1.33	0.33± 0.07
RSSSC-C_0×B79	234.5	127.0	7.73
RSSSC-C_1×B79	235.4	133.0	8.13
RSSSC-C_2×B79	234.9	133.5	7.92
RSSSC-C_3×B79	245.4	143.6	8.34
b_1	3.2± 0.94	5.1± 1.33	0.16± 0.07

$^+b_1$ values greater than twice standard error are considered significantly different from zero.

response to selection in 300-kernel weight. The BS10 also had significantly increased kernel number/ear (b_1=23.5). Changes of grain moisture from selection were only observed in BS10 (b_1=0.5%) and BS10×B37 (b_1=0.4%). After three cycles of selection grain yield improvement in BS10 was mainly due to increase in both 300-kernel weight and kernel number/ear, while in RSSSC the yield increase was mainly due to increase in 300-kernel weight (Table 3).

Multiple leaf disease resistance and multiple stalk-rot resistance were improved in

Table 3. Means and linear regression coefficients for ear number/100-plants, 300-kernel weight, kernel number/ear, and grain moisture of BS10 and RSSSC populations improved by three cycles of reciprocal recurrent selection in a high-yield environment, and measured at HYE, Illinois, 1985.

Population	Ear number/100 plants	300-Kernel weight (g)	Kernel number/ ear	Grainmoisture (%)
BS10-C_0	126.3	99.1	317.8	18.8
BS10-C_1	115.1	100.1	337.3	19.2
BS10-C_2	112.6	107.3	347.4	20.0
BS10-C_3	107.4	111.1	392.8	20.3
b_1^+	-5.9 ± 1.15	4.3 ± 1.33	23.5 ± 7.17	0.5 ± 0.16
RSSSC-C_0	102.6	98.6	394.5	19.8
RSSSC-C_1	103.3	100.0	385.1	19.6
RSSSC-C_2	104.0	108.6	394.9	19.6
RSSSC-C_3	102.7	111.8	397.6	20.6
b_1	0.1 ± 1.15	4.8 ± 1.33	1.9 ± 7.17	0.2 ± 0.16
BS10-$C_0\times$RSSSC-C_0	104.6	108.9	386.6	19.2
BS10-$C_1\times$RSSSC-C_1	107.4	110.8	408.3	19.4
BS10-$C_2\times$RSSSC-C_2	104.9	112.1	419.9	19.2
BS10-$C_3\times$RSSSC-C_3	107.9	114.4	399.5	20.3
b_1	0.7 ± 1.15	1.8 ± 1.33	5.0 ± 7.17	0.3 ± 0.16
BS10-$C_0\times$B37	106.6	104.5	387.0	19.7
BS10-$C_1\times$B37	100.7	108.9	401.6	19.9
BS10-$C_2\times$B37	100.0	109.9	402.1	19.9
BS10-$C_3\times$B37	102.0	110.5	418.1	21.0
b_1	-1.5 ± 1.15	1.9 ± 1.33	9.4 ± 7.17	0.4 ± 0.16
RSSSC-$C_0\times$B79	107.3	109.4	422.4	21.0
RSSSC-$C_1\times$B79	108.9	106.0	426.8	20.5
RSSSC-$C_2\times$B79	109.4	104.6	410.1	20.7
RSSSC-$C_3\times$B79	115.1	110.9	418.0	20.8
b_1	2.4 ± 1.15	0.3 ± 1.33	-3.0 ± 7.17	-0.1 ± 0.16

$^+b_1$ values greater than twice standard error are considered significantly different from zero.

populations *per se* and population crosses (Table 4). Selection responses were similar among populations and population crosses. Means of three ratings showed that BS10, RSSSC and BS10×RSSSC had a 4.3, 4.5 and 4.5%/cycle significant decrease in percent leaf area infected, respectively. After three cycles of selection BS10, RSSSC and BS10×RSSSC had a 1.1, 0.7 and 1.2 unit/cycle decrease in multiple stalk-rot rating (scale 1 resistant—9 susceptible), respectively. Several researchers have shown that recurrent selection was effective in improving resistance to corn leaf blight [12,23,24] and Stalk-rot

Table 4. Means and linear regression coefficients (b_l) for multiple leaf disease and multiple stalk rot ratings of BS10 and RSSSC populations improved by three cycles of reciprocal recurrent selection, and evaluated in disease nursery, Urbana, Illinois, 1985.

Population	Multiple leaf disease (% leaf area infected)	Multiple stalk rot (1-9 scale)
BS10-C_0	44.8	8.1
BS10-C_1	37.9	7.4
BS10-C_2	36.1	6.4
BS10-C_3	31.0	4.7
b_l^+	−4.3± 0.52	−1.1± 0.26
RSSSC-C_0	51.3	8.6
RSSSC-C_1	47.3	7.5
RSSSC-C_2	43.4	7.2
RSSSC-C_3	37.7	6.2
b_l	−4.5± 0.52	−0.7± 0.26
BS10-C_0×RSSSC-C_0	44.2	8.4
BS10-C_1×RSSSC-C_1	40.4	6.9
BS10-C_2×RSSSC-C_2	34.2	6.1
BS10-C_3×RSSSC-C_3	31.3	4.7
b_l	−4.5± 0.52	−1.2± 0.26

^+b_l values greater than 2.052 standard error are considered significantly different from zero.

[13,20,23,24,30]. Our data indicate that three cycles of phenotypic mass selection largely increased multiple leaf disease and multiple stalk-rot resistance for populations *per se* and population crosses. This agrees well with results from other works.

Reported results from use of recurrent selection usually have been positive. Response to grain yield in intrapopulation improvement has been approximately 2 to 4% per cycle of selection [9]. Direct response to reciprocal recurrent selection has varied from 3.1% per cycle for BSSS×BSCB1 in Iowa to 6% for "Teko Yellow Horsetooth" and " Natal Yellow" in South Africa and 7 % for "Kitals Synthetic II" and "Ecuador 573" in Kenya, East Africa. Indirect response to selection for the base populations *per se* varied from 0 to 7% per cycle [3,11,25,27,29]. Direct responses to reciprocal full-sib selection in the population cross was 2.1% [10]. Correlated response in BS10 and BS11 was 2.7 and 2.4%, respectively. Despite of different selection intensities and different cycles of selection used in different breeding programs, a gain of 11.5, 7.7 and 6.8% per cycle for grain yield obtained in this study for BS10, RSSSC and BS10×RSSSC, respectively, compare favorably with published reports.

Gain from three cycles of reciprocal recurrent selection was satisfactory in the populations *per se*, population crosses and populations×testers for grain yield, multiple leaf disease resistance and multiple stalk-rot resistance. Stalk lodging resistance was

improved in population BS10 and population crosses. Correlated changes in other agronomic traits were mostly desirable. The result suggests that the procedures of HYE selection are beneficial in developing maize population *per se* and hybrids with high grain yield, multiple leaf disease resistance, multiple stalk-rot resistance and good stalk quality.

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玉米族羣相互輪迴選拔之選種效應評估[1]

盧煌勝[2] R. J. Lambert[3]

摘要

在高產環境下，利用 BS10及RSSSC 兩個玉米族羣進行兼顧族羣內及族羣間改良之相互輪迴選拔。族羣內之改良包括多種葉斑病、莖腐病等抗病性的外表型混合選種及S_1系統在高產環境下之產量評估。族羣間之改良則包括測交系統在高產環境下之產量試驗及選拔。三個輪迴之選種效應評估，分別利用族羣、族羣雜種及族羣測交種等，於四個不同環境下進行產量試驗；並利用族羣及族羣雜種於病圃檢定其對葉斑病及莖腐病之抵抗性。試驗結果摘要如下：

（1）選拔效應不因評估環境之不同而有明顯差異。

（2）族羣本身、族羣雜種以及族羣測交種之子實產量、多種葉病與莖腐病之抵抗性等之改良效果頗爲顯著。在子實產量方面， BS10, RSSSC, BS10×RSSSC, BS10×B37，及 RSSSC×B79分別達到0.95、0.69、0.65、0.65及0.24噸／公頃／輪迴之增進效果。在抗倒伏性方面，BS10, BS10×RSSSC及BS10×B37分別爲−9.0、−5.4及−3.5%／輪迴之選種效應。所有族羣、族羣雜種及族羣測交種之Penetrometer reading亦顯著地增强。

（3）就本研究之育種目標而言，相關性狀之改變，以合意者居多。其中較爲不利之變化爲RSSSC, BS10×RSSSC及RSSSC×B79等之株高及穗位高之增加，及BS10 每株穗數之減少。有利的部分則包括BS10之300粒重及每穗粒數，及RSSSC 300粒重之增加等。

（4）本試驗結果顯示：高產環境下進行相互輪迴選拔，對改良玉米子實產量、病害抵抗性及抗倒伏性成效頗著，爲一有利的選拔方式。

1.臺灣省農業試驗所 研究報告第 1430 號。
2.本所農藝系副研究員。臺灣省 臺中縣 霧峰鄉。
3.美國伊利諾大學農藝系遺傳學教授。

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玉米對溫度與光週期之生長反應[1]

王強生　王碧玉　劉大江[2]

摘要：以玉米單雜交品種臺農351號與其母本 TA80-2598及父本TA80-1410 爲材料，於生長箱中五種光期與溫度組合條件下栽培，並於3、7、9及12月室外盆栽，探討溫度與光期對葉原體分化速率、葉齡及生育日數的影響。高溫（33/25 ℃）狀況較長光期（14 hr）之玉米雄穗分化始期葉齡較短光期（12 hr）處理爲高，但對葉原體數目並無影響，最終葉數則因品種（系）而有異；較長光期又使母本自出土至幼穗分化始期、抽穗及開花之日數延長，唯對父本及雜交種之作用不明顯或有縮短的趨勢。同一光期（12 hr）而溫度由 23/15℃或 18/10 ℃時，雄穗分化始期葉齡及葉原體數目減小，最終葉數相近，出葉速率亦呈降低趨向，而植株發育至雄穗分化始期所需日數漸增；比較 33／25 與 28/20 ℃溫度處理結果，母本及雜交種植株自出土至抽穗、開花與吐絲所需日數差異並不明顯，或反以前者爲高，可能爲品種特性或過高之溫度並不能顯示溫度累積效應，此一推論可由室外盆栽試驗7月（較高溫）及9月（較低溫）播種處理之類似結果得到佐證。田間與生長箱高溫狀況下，玉米植株在雄穗分化始期（葉齡爲10）以前之出葉速率多高於分化始期以後之出葉速率，顯示營養生長期與生殖生長期具有不同的生育特性，對環境因子的反應也具有程度上的差異。室外試驗與生長箱試驗結果相互吻合，並認爲臺中地區栽培玉米之生長受溫度的影響較光期爲大；於7至9月間播種時，植株葉數多，出葉速率快，營養生長量充足而生育期不致太長，應爲適宜之栽培時期。

玉米臺農 351 號爲目前國內主要栽培品種之一，其父本 TA80-1410 屬溫帶型馬齒種，母本 TA80-2598 爲熱帶型硬粒種 (1)；此二自交系於民國 72 年秋作栽培時，曾發生父本抽穗期與母本吐絲期配合欠佳，導致生產雜交種子困難，而當年春作則無此現象發生，推測應爲環境因子影響的結果。又由74年秋作臺農351號玉米全省栽培試驗資料 (17) 顯示，就同地區而言一，播種期愈晚，植株發育至抽穗、吐絲及成熟期所需日數愈長，且差異極爲明顯，亦證明本省環境因子對經濟栽培玉米具有顯著的作用。

溫度與光週期爲影響玉米植株生長及分化的兩項重要因子，Francis et al. (9,10)、Garner and Allard (11) 與 McClelland (18) 指出玉米對光期敏感，呈短日反應；Breuer et al. (6) 與 Francis et al. (10) 報告在長日條件下，玉米雄穗分化始期（tassel initiation）及開花期（anthesis） 有延遲現象。另一方面，溫度可能影響玉米之光期反應 (19)，Russel and Stuber (20) 即曾報告愈晚熟品種在長日處理下的葉數愈多，抽穗期亦愈遲，但此種現象又隨溫度之升高而漸不明顯；Hunter et al. (14,15) 指出低溫及長日條件下，玉米雄穗分化始期延後，高溫則可增加葉數；Tollenaar and Hunter (23) 認爲延長光期及升高溫度均可增加葉數，且二者有加成效果。Warrington and Kanemasu (24,25,26) 並曾進行系列試驗，將溫度與光期對玉米發芽、雄穗分化始期、開花期、葉數及出葉速率的影響

1.臺灣省農業試驗所　研究報告第 1431 號。本試驗承行政院農業委員會補助（74農建—2.2—糧—27—6），謹致謝意。

2.分別爲本所農藝系助理研究員、約僱技術員與研究員。臺灣省臺中縣霧峰鄉。

做定量描述，發現其影響並非簡單直線關係，而係以多次曲線關係存在。

綜合上述研究結果，可知溫度與光期確實影響玉米生長；依據農民曆記載，臺灣地區全年日長介於 10.5 至 14.5 小時之間，而玉米營養生長期間之日長差異更小；又依據中央氣象局農業旬報資料，72 年 8 月上旬至 12 月下旬，各地平均溫差高達 15° C，因此臺灣地區溫度影響玉米生長與分化之效應是否高於光期，為一項值得探討的問題。本試驗以玉米臺農 351 號及其父、母本為材料，探討對溫度與光期的生長反應，所得資料配合相關栽培試驗結果，應可對本省玉米採種與生產工作提供學理與應用之依據。

材料與方法

試驗採用玉米單雜交品種臺農 351 號（Tainung 351）及其父本 TA80-1410 與母本 TA80-2598為材料，於民國 73 年12 月至 74 年 12 月利用植物生長箱 (Conviron PGW-36, Controlled Environments, Ltd., Canada) 及於室外以盆栽方式進行試驗。生長箱試驗包括 14 hr 光期與溫度（日／夜）33/25 °C—處理，及 12 hr光期與溫度 33/25、28/20、23/15及18/10 °C 四處理，光度為 400μE/m²/sec，相對濕度為 85%。室外盆栽試驗係於 73 年 12 月 12 日、74 年3 月 22 日、7 月 1 日及 9 月 5 日播種。

播種時採用18.5 1 (直徑 28cm，高 30cm，約合 1/2,000 a) 之圓形栽培缽，每缽 4 穴，每穴 2 粒種子，出土後每穴留一株。每處理種植25缽，生長箱內置15缽，其餘供室外試驗用。肥料用量為每一植缽N：K_2O：P_2O_5＝1.50：0.75：0.70 g，分三次施用，並予適量灌溉。

性狀調查係自幼苗出土後至雄穗抽出之間進行，以每株為一重複，每次至少調查 6 株。調查之性狀包括：

1. 葉齡：依葉片展開程度分為 n、n+0.25、n+0.5 與 n+0.75 四階段 [13,21]，每隔 1—2 日調查一次。
2. 雄穗分化始期：依據 Bonnett [5] 與 Warrington and Kanemasu [24] 之標準，解剖觀察雄穗分化始期，並計算此時之葉原體數目 [23]；解剖調查係自第 7 葉齡開始，每隔 1—2 日進行一次，每次自不同植缽選取一株，合計 6 株以上予以調查，雄穗分化始期以後，每缽均僅留 2 株繼續栽培。
3. 雄穗抽出期、開花期及吐絲期：自幼苗出土起計算所需日數。
4. 最終葉數：於雄穗抽出後計算總葉數。
5. 出葉速率：分為幼苗出土至雄穗分化始期及至雄穗抽出期兩個階段，計算平均每日出葉數目 [15,21,22]。

結果與討論

試驗進行期間室外之溫度、日照時數及日長等氣象資料列於表 1；平均日長以 6 月之 13.6 hr最長，12 月之 10.6 hr 最短，差距為 3 hr；如以一般玉米栽培季節而言，春作營養生長期（3—6 月）日長為 12.0—13.3 hr，秋作（9—10月）為 11.1—12.3 hr，差異更小。月平均溫度 7 月為 28.2 °C，1 月為 16.2 °C，差距達 12 °C；玉米春作營養生長期間為18.5—26.7 °C，秋作為 25.5—27.0 °C，以前者初期之溫度較低。基於歷年溫度與日長資料，本試驗各處理較著重溫度變化之效應。

於室外盆栽臺農351號及其父本TA80-1410與母本 TA80-2598，四個播種期之雄穗分化始期葉齡均以12月播種者最大，為 9.75—10.38，3 月播種者最小，介於 8.50—8.71（表 2），7 及 9 月播種者差異較不明顯，顯示播種後生育初期氣溫愈低，植株發育至雄穗分化始期時之葉齡愈大。

經由解剖觀察雄穗分化始期之葉原體數目（表 2），有 7 及 9 月播種者較多、而12月播種者較少的趨勢，顯示播種後溫度較高則葉原體數目亦多，與Hunter et al. [15] 及Tollenaar and Hunter [23] 之結果相符；唯三品種（系）的表現仍具程度性差別，以臺農 351 號品種的差異較為明顯。在植株最

Table 1. Monthly mean temperature, sunshine duration and day-length at Wufeng (Taichung) area from Sept., 1984 to Dec., 1985*

Item	1984				1985			
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Temperature (C)								
Mean	27.2	25.5	22.5	17.9	16.2	18.4	18.5	22.0
Maximum	33.2	32.7	29.9	25.7	22.7	22.9	26.1	29.6
Minimum	23.1	19.5	16.0	11.3	10.3	15.1	15.3	17.7
Sunshine								
Duration (hr)	7.9	7.7	6.0	5.4	6.9	3.7	6.9	6.7
Day-length (hr)					10.8	11.4	12.0	12.7

	1985							
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temperature (C)								
Mean	26.7	27.0	28.2	27.8	27.0	25.5	21.3	16.8
Maximum	32.3	32.0	33.5	34.0	32.0	30.4	28.1	25.9
Minimum	22.7	23.5	24.3	23.7	22.9	21.2	16.0	8.8
Sunshine								
Duration (hr)	8.9	4.4	6.7	6.7	8.3	8.3	7.9	7.6
Day-length (hr)	13.3	13.6	13.5	13.0	12.3	11.1	11.0	10.5

* Temperature and sunshine duration data are from Agrometereological Bulletin of Central Weather Bureau, ROC; day-length data are from Taiwan Provincial Food Bureau.

Table 2. Leaf number at tassel initiation (T. I.) of corn inbreds TA80-2598 and TA80-1410 and their F-1 hybrid Tainung 351 grown under natural conditions

Inbred/Hybrid	Sowing Date (Mon/Day/Yr)	Emerged Leaf No. at T. I. (A)	Leaf No. Counted at T. I. *(B)	Final Leaf No. (C)	A/B	B/C
TA80-2598	3/22/85	8.50c**	17.8b	18.2b	0.477c	0.98b
	7/ 1/85	9.50b	18.1ab	19.5a	0.525b	0.92c
	9/ 5/85	9.36c	19.3a	19.8a	0.485c	0.97b
	12/12/84	10.38a	17.5b	17.0c	0.593a	1.03a
TA80-1410	3/22/85	8.77c	18.3ab	19.7a	0.503b	0.93b
	7/ 1/85	9.43b	18.4ab	18.0b	0.513b	1.02a
	9/ 5/85	9.28bc	18.9a	18.5b	0.491b	1.02a
	12/12/84	9.75a	17.7b	18.0b	0.551a	0.98b
Tainung 351	3/22/85	8.71c	18.3bc	19.2a	0.476c	0.95a
	7/ 1/85	9.54b	18.8ab	19.8a	0.507b	0.94a
	9/ 5/85	9.34b	20.0a	20.2a	0.467c	1.00a
	12/12/84	10.33a	17.3c	18.0b	0.597a	0.96a

* Leaf number counted by anatomical examination.

**Means followed by the same letter within each column of an inbred/hybrid are not significantly different at 5% level by Duncan's New Multiple Range Test.

終葉數（表 2）方面，臺農 351 號以 12 月低溫播種者最少（18.0葉），其餘三個播種期間的差異不顯著；母本 TA80-2598 有相似的表現，亦以 12 月播種處理最低，但三月播種植株葉片數目少於 7 及 9 月播種處理，對溫度的反應最爲明顯；反之，父本 TA80-1410 之葉數以三月播種最多，12 月低溫與 7 及 9 月高溫狀況下播種之葉數則相近，亦即品種（系）間的表現有異。

雄穗分化始期葉齡與葉原體數目比值（表 2 中之 A/B）介於 0.477—0.597 之間，依據 Tollenaar and Hunter [23] 的報告，自然狀況下植株發育至總葉數一半時，雄穗即開始分化；以臺農 351 號爲例，室外栽培至葉齡爲 9 時，約相當於雄穗分化始期，可用爲栽培管理之依據。上述葉齡與葉原體數目比值均以 12 月播種者最高，可能亦以低溫之效應爲主。雄穗分化始期解剖計算葉原體數目（B），與最終葉數（C）之比值介於 0.92—1.03 之間，兩親本在處理間之差異並達顯著水準，唯經由資料分析，仍可確定玉米雄穗分化始期時葉片數目業已決定。

生長箱試驗中有關葉數性狀資料列於表 3；溫度同爲 33/25 °C時，植株在 14 hr 光期下發育至雄穗分化始期之葉齡爲 10.29—10.50，顯著較 12 hr與 33/25 °C處理之結果（9.55—9.72）爲高，表示在高溫情況下之長日處理效果，與Tollenaar and Hunter [23] 與 Warrington and Kanemasu [26] 結果相同。然而臺農 351 號於雄穗分化始期之葉原體總數反以短日處理（12 hr）者爲低，兩個自交系並未反應長日效果，最終葉數亦然（表 3）。根據 Warrington and Kanemasu [26] 報告，延長光期

Table 3. Leaf number at tassel initiation (T. I.) of corn inbreds TA80-2598 and TA80-1410 and their F-1 hybrid Tainung 351 grown under different temperature at 12-or 14-hr light period in growth chambers

Inbred/Hybrid	Light Period (hr)	Day/night Temperature (C)	Emerged Leaf No. at T. I. (A)	Leaf Number Counted at T. I. *(B)	Final Leaf No. (C)	A/B	B/C
TA80-2598	14	33/25	10.50a***	19.9a	19.8a	0.528a	1.01a
	12	33/25	9.55b	19.9a	19.3a	0.479b	1.03a
	12	28/20	8.64c	17.9bc	18.1b	0.483b	0.99a
	12	23/15	8.15d	17.1c	19.4a	0.477b	0.88b
	12	18/10	8.53c	18.6b	17.9b	0.459b	1.05a
TA80-1410**	14	33/25	10.29a	18.2ab	18.0a	0.566a	1.01a
	12	33/25	9.66b	19.0a	17.9a	0.508b	1.07a
	12	28/20	9.00c	18.3a	17.8a	0.492b	1.03a
	12	23/15	7.81d	17.2b	18.2a	0.454c	0.95b
Tainung 351	14	33/35	10.45a	19.0b	19.1a	0.550a	0.99ab
	12	33/25	9.72b	20.2a	19.1a	0.486b	1.06a
	12	28/20	8.53c	18.0c	17.6c	0.474bc	1.02a
	12	23/15	8.08d	17.7c	20.6a	0.456c	0.86c
	12	18/10	8.50c	18.4b	18.5bc	0.462c	1.03a

* Leaf number counted by anatomical examination.

** TA80-1410 plants did not survive at low temperature of 18/10 C.

*** Means followed by the same letter within each column of an inbred/hybrid are not significantly different at 5% level by Duncan's New Multiple Range Test.

爲葉數增加的主要原因之一，日長每增 1 hr 時，葉數增多 0.21—0.38，又綜合 Bonaparte [4]、Coligado and Brown [7]、Hesketh et al. [12] 與 Hunter et al. [14] 等之研究，日長每增 1 hr 時，葉數增加幅度爲0.21—0.58，應可確定日長對葉數的影響；本試驗中未能獲致完全相同的結論，主要原因可能爲日長處理差距僅爲 2 hr，又係於高溫下進行比較，日長效應因而較不明顯。

比較同爲 12 hr 光期時之溫度處理效應（表 3），發現隨溫度之降低（由 33/25 °C 至 23/15 °C），三品種（系）於雄穗分化始期之葉齡及葉原體數均顯著減少，但最終葉數之反應較不明顯；Warrington and Kanemasu [26] 認爲高溫時玉米的葉數較多，溫度每升高 1 °C 時，增加 0.13—0.44葉，本試驗中自交系TA80-1410 之葉數不受溫度影響，TA80-2598 與臺農351號之葉數則以 33／25與 23/15 °C處理高於 28／20 與 18/10 °C 處理，結果並不一致，是否爲日長效應、品種特性或取樣差異之影響，猶待確定。

室外及生長箱試驗玉米植株自出土至雄穗開始分化、抽穗、開花及吐絲所需日數，分別列於表 4 與表 5。室外試驗部份，植株發育至任一特定生育階段所需時間，均以 12 月播種者最長，3 月次之，7 及 9 月播種者最短且兩處理間多無顯著差異（表 4），亦即在 12月播種後之低溫短日條件下，玉米植株的生長分化有延緩現象，7 及 9 月播種後之高溫長日下較爲快速；玉米對光期原呈短日反應 [6,10]，但此一反應又爲溫度左右 [19,20,23]，本省地處亞熱帶，日長差異最多不超過 4 hr，而平均溫度差異高達 12 °C以上（表 1），可能溫度對玉米植株的影響超過日長，爲導致試驗結果的主要原因。

3 月與 9 月播種玉米約與本省春、秋作時間相近，其抽穗與吐絲日數分別爲 60—62 日與 68—70 日及 48—49日 與 55—57日，與本所農場管理室進行臺農 351 號親本播種期試驗的結果相同（未發表

Table 4. Days from seedling emergence to tassel initiation, tasseling, anthesis and silking of corn inbreds TA80-2598 and TA80-1410 and their F-1 hybrid Tainung 351 grown under natural conditions

Inbred/Hybrid	Sowing Date (Mon/Day/Yr)	Days from Seedling Emergence to			
		T. I. *	Tasseling	Anthesis	Silking
TA802598	3/22/85	27.0b**	60.6b	65.4b	68.5b
	7/ 1/85	19.3c	49.5c	53.2c	57.5c
	9/ 5/85	18.6c	49.0c	51.8c	56.8c
	12/12/84	75.0a	117.0a	120.2a	128.8a
TA80-1410	3/22/85	26.8b	60.5b	66.8b	69.8b
	7/ 1/85	18.6c	45.0d	55.5c	57.3c
	9/ 5/85	18.9c	48.5c	51.3d	55.0c
	12/12/84	74.0a	120.1a	124.3a	130.7a
TA80-1410	3/22/85	26.6b	61.8b	65.6b	69.9b
	7/ 1/85	19.5c	48.5c	54.2c	55.3c
	9/ 5/85	17.1d	48.5c	51.5d	56.3c
	12/12/84	69.0a	113.4a	117.0a	125.1a

* Tassel initiation.

** Means followed by the same letter within each column of an inbred/hybrid are not significantly different at 5% level by Duncan's New Multiple Range Test.

資料）；秋作玉米於 7 月以後至氣溫開始大幅下降（10月）以前播種，植株葉數多，營養生長量充足，乾物重最高（資料未列出），且生育期不致太長，應爲適當的栽培季節。如於 12 月播種，玉米自出土至抽穗與吐絲期的時間約爲 110—130日，亦即低溫導至生育期過度延長；前述臺農 351 號親本播種期試驗於 10 月下旬及 11 月下旬播種時，由播種至吐絲日數爲 90—121 日，至成熟期爲 152—167 日，產量亦低，對栽培管理與適應輪作制度而言，均屬不宜。

生長箱試驗結果（表 5）顯示，同爲高溫（33/25 °C）情況下，光期較長（14 hr）處理使母本 TA80-2598 生長至雄穗分化期之時間延長，父本 TA80-1410 與臺農 351 號雖未具顯著之處理間差異，似有相似趨勢；短日本有提早雄穗分化之效果[3,24]，Kiniry[16] 以不同玉米品種試驗，發現光期由 12.5 hr 增至 17.5 hr 時，雄穗分化始期延遲 3.5—12日；Hunter et al.[14] 認爲此一效果對中、晚熟品種尤其明顯。光期對出土至抽穗、開花與吐絲日數的影響並不一致（表 5），且多以短日處理（12 hr）之日數較長，其確切原因不明，唯株間變異較大與光期差距較小爲可能之影響因子。

光期爲 12 hr 時，溫度對玉米生育之影響結果列於表 5；23/15 °C 處理由於生長箱故障，18/10 °C處理由於父本無法生長，致缺少部分資料。比較 33／25 與 28/20 °C 處理，高溫明顯縮短至雄穗分化所需要的時間，延長臺農 351 號至抽穗及三個品種（系）至開花與吐絲的日數，似乎顯示高

Table 5. Days from seedling emergence to tassel initiation, tasseling, anthesis and silking of corn inbreds TA80-2598 and TA80-1410 and their F-1 hybrid Tainung 351 grown under different temperatures at 12-or 14-hr light period in growth chambers

Inbred/Hybrid	Light Period (hr)	Day/Night Temperature (C)	Days from Seedling Emergence to			
			T. I. *	Tasseling	Anthesis	Silking
TA80-2598	14	33/25	29.1c**	61.3b	71.3b	73.5c
	12	33/25	25.4d	58.8c	67.5c	75.3b
	12	28/20	28.8c	57.1c	62.3d	65.1d
	12	23/15	38.7b	—***	—	—
	12	18/10	63.8a	115.2a	120.0a	124.4a
TA80-1410****	14	33/25	28.6c	59.5b	68.0b	70.6b
	12	33/25	27.2c	64.4a	72.1a	78.3a
	12	28/20	31.1b	63.4a	66.8b	66.0c
	12	23/15	35.6a	—	—	—
Tainung 351	14	33/25	27.3c	58.7c	66.4b	71.8c
	12	33/25	25.6c	61.0b	67.8b	74.4b
	12	28/20	28.0c	56.9c	61.4c	64.8d
	12	23/15	38.5b	—	—	—
	12	18/10	63.9a	117.9a	122.4a	128.0a

*Tassel initiation.

**Means followed by the same letter within each column of an inbred/hybrid are not significantly different at 5% level by Duncan's New Multiple Range Test.

***Data not available due to disorder of growth chambers.

****TA80-1410 plants did not survive at low temperature of 18/10 C.

溫的作用並不一致，但由於超過 30 °C 以上之溫度度數對多數玉品米種之發育不一定能顯示溫度累積效應，甚至產生高溫逆境作用 (8) ，本試驗之結果亦屬可能，此項推論可由室外試驗 7 月及 9 月播種處理之類似結果（表 4）得到佐證 。當溫度降低至 18/10 °C 時，玉米植株發育至雄穗分化、抽穗、開花與吐絲日數所需時間最長，約爲 28/20 °C 處理之二倍，且與室外 12 月播種之結果極爲接近，顯示低溫之顯著影響。

表 6 資料爲室外試驗之出葉速率，以每日之出葉數目表示（以下同）；四個播種期中以 12 月播種者之出葉速率最慢，三個品種（系）都有相同表現，其中出土至雄穗分化始期左右（以第10葉齡爲區分標準）之出葉速率爲 0.126—0.137，而出土至抽穗期間的出葉速率較快，介於 0.140—0.158 之間，溫度升高應爲主要的影響因子之一。三月播種處理之出葉速率較高，但仍顯著低於 7 及 9 月高溫播種之結果；Tollenaar et al. (22) 即曾指出在 15 至 30 °C 之間，溫度對出葉速率有正向作用，本試驗所得結果並與 Warrington and Kanemasu (26) 的報告相符合。

Table 6. Rate of leaf appearance (leaves/day) during two growth periods of corn inbreds TA80-2598 and TA80-1410 and their F-1 hybrid Tainung 351 grown under natural conditions

Sowing Date (Mon/Day/Yr)	Inbred/Hybrid		
	TA80-2598	TA80-1410	Tainung 351
	Seedling emergence to tassel initiation (Leaf No. 1 to 10)		
3/22/85	0.291^{b}	0.287^{c}	0.300^{c}
7/ 1/85	0.483^{a}	0.487^{a}	0.501^{a}
9/ 5/85	0.453^{a}	0.412^{b}	0.469^{b}
12/12/84	0.137^{c}	0.126^{d}	0.132^{d}
	Seedling emergence to tasseling (Leaf No. 1 to final leaf number)		
3/22/85	0.290^{c}	0.316^{b}	0.301^{b}
7/ 1/85	0.405^{a}	0.375^{a}	0.433^{a}
9/ 5/85	0.386^{b}	0.367^{a}	0.402^{a}
12/12/84	0.154^{d}	0.140^{c}	0.158^{c}

*Means followed by the same letter within each column of an inbred/hybrid are not significantly different at 5% level by Duncan's New Multiple Range Test.

**TA80-1410 plants did not survive at low temperature of 18/10 C.

生長箱試驗中玉米出葉速率對溫度的反應資料列於表 7；在 18/10 °C低溫處理時，臺農 351 號品種及其母本 TA80-2598 出土至雄穗分化始期左右之速率爲 0.114 與 0.113 ，而出土至抽穗期間則介於 0.187—0.198， 以後者較高， 顯然在本試驗低溫條件下 ，雄穗分化始期以後之出葉速度較快，高溫環境下則無類似表現 （表 7） 。綜合比較其他三個溫度（28／20 及 33/25 °C） 與日長 （12及 14 hr） 處理，除少數例外，並無明顯之溫度作用；雖然 Warrington and Kanemasu (25) 報告在16至 26 °C範圍內，溫度每升高 1 °C即提高出葉速率 0.23，且 30—34 °C 時可獲得最高之出葉速率，但 Tollenaar et al. (22) 則指出當溫度超過 30 °C 時反有下降之趨勢；本試驗爲配合田間實際生長條件，僅選用 33／25 與 28／20 兩種高溫處理，日溫差距爲 5 °C，且最高溫超過 30 °C，此外，出葉速率亦受品種、光量、光期、光質與栽培方法的共同影響，可能爲兩溫度處理作用不顯著的主要原因。

Table 7. Rate of leaf apperarance (leaves/day) during two growth periods of corn inbreds TA80-2598 and TA80-1410 and their F-1 hybrid Tainung 351 grown under different temperature regimes at 12-or 14-hr light period in growth chambers

Light Period (hr)	Day/Night Temperature (C)	Inbred/Hybrid		
		TA80-2598	TA80-1410	Tainung 351
		Seedling emergence to tassel initiation (Leaf No. 1 to 10)		
14	33/25	0.352[a]*	0.329[a]	0.396[a]
12	33/25	0.365[a]	0.333[a]	0.349[ab]
12	28/20	0.313[ab]	0.267[b]	0.315[b]
12	18/10	0.113[c]	—**	0.114[c]
		Seedling emergence to tasseling (Leaf No. 1 to final leaf number)		
14	33/25	0.324[a]	0.325[a]	0.310[a]
12	33/25	0.316[a]	0.276[b]	0.303[a]
12	28/20	0.308[a]	0.283[b]	0.288[ab]
12	18/10	0.187[b]	—	0.198[c]

*Means followed by the same letter within each column of an inbred/hybrid are not significantly different at 5% level by Duncan's New Multiple Range Test.

**TA80-1410 plants did not survive at low temperature of 18/10 C.

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Growth Responses of Corn to Temperature and Photoperiod

C. S. Wang, P. Y. Wang and D. J. Liu

Summary

The single-cross corn Tainung 351 and its paternal inbred TA80-1410 and maternal inbred TA80-2598 were used to study the influences of temperature and photoperiod on the initiation rate of leaf primordia, leaf age and duration of growth in corn. Plants were cultured in the growth chamber under five combinations of temperatures and photoperiods. Plants were also sown in March, July, September and December of the year and cultured under natural conditions to confirm the results of growth-chamber study. At high temperature (33/25 C), plants under longer photoperiod (14 hr) showed a higher leaf age at tassel initiation (TI) than those grown under shorter photoperiod (12 hr). However, number of leaf primordia at TI was not affected and the response of final leaf number was erratic among the three corn materials. In addition, the longer photoperiod tended to delay TI, tasseling and anthesis in TA80-2598. The effect was less clear in TA80-1410 and the hybrid. When temperature was lowered from 33/25 C to 23/15 C or 18/10 C at 12-hr photoperiod, leaf age and number of leaf primordia at TI, as well as leaf appearance rate decreased while final leaf number remained the same. Days from seedling emergence to TI also increased as a result of the lowered temperature. Comparison between temperature treatments of 33/25 and 28/20 C indicated that days needed from seedling emergence to tasseling, anthesis and silking were not significantly different in most cases or even longer for the 33/25 C treatment. The results suggested the existence of varietal variations or lack of accumulated temperature effect under extreme temperatures. The assumption was confirmed by the outdoor experiment in which similar results were obtained between the Juiy (high temperature) and September (relatively low temperature) sowings. Leaf appearance rate was higher in the vegetative growth (seedling emergence to leaf age 10) than in the reproductive growth (after leaf age 10), suggesting different growth responses to environmental factors between the two phases of development. In most instances, results of the outdoor experiment were in agreement with those of the growth-chamber study in terms of the temperature effects. It was also concluded that for corn grown in Taichung area, the influences of temperature were more significant than those exerted by photoperiod. Sowing corn between July and September was considered suitable as plants tended to possess more leaves, higher leaf appearance rate and sufficient vegetable growth with an appropriate growth duration.

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2. Respectively, assistant agronomist, assistant and senior agronomist, Department of Agronomy, TARI, Wufeng, Taichung Hsien, Taiwan 41301, ROC.

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落葉劑與剪葉處理對於大豆成熟期、產量及品質之影響[1]

林順福　陳　成[2]

摘要　本試驗於大豆 R6（full seed）時期以三種不同濃度（1D，2D，3D）落葉劑，和剪除上半部，下半部及全部葉片處理 TNG 4，TNG 15，KS 8 與 M34—1 等四品系（種），探討落葉劑及剪葉處理對提早成熟期之效果與其對產量、品質之影響，並評估提早成熟期與產量之關係，以供栽培及育種參考，結果摘要條列如下：

一、落葉劑 paraquat 及剪葉處理均可獲致提早成熟期與降低倒伏率之效果，但同時會造成產量嚴重損失及種子品質低落等不良影響。

二、使用之三落葉劑濃度間對產量降低之影響無顯著差異，然而隨濃度增加，可獲較佳提早成熟期與降低倒伏率效果。

三、除 TNG 15 外，其他三品種（系）剪除具有遮蔭效果之上半部葉片或下半部葉片，均未顯著提早成熟期，但均會降低產量，顯見大豆生育後期遮蔭作用並非決定成熟期之關鍵，但剪除全部葉片則可顯著提早成熟期。

四、落葉劑及剪葉處理造成產量嚴重損失，係因莢數與百粒重同時降低所致。

五、以落葉劑及剪葉處理提早成熟期七天，將造成約30%以上產量損失，故除非為防止天然災害，否則不值得採用。

本省春作大豆生育後期適值雨季及颱風季節，常因日照不足及地面潮溼造成植株倒伏及病害發生，影響產量及品質；而夏作及裡作則為調整農時，和避免生育期過長，影響下一期作物之播種期，均亟需早熟而抗倒伏之品種，在現有推廣品種未能滿足此種特殊環境需要之際，農民常噴灑落葉劑或剪除全部葉片，以促進早熟，但都可能造成產量及品質之降低。因此，本試驗之目的即在探討使用落葉劑及剪葉處理對大豆成熟期及產量與品質等性狀之影響，並評估提早成熟期與犧牲產量間之得失利弊，以作為栽培及育種上之參考。

材料與方法

（一）參試品種（系）：

1. M34—1	（亞蔬品系）	早熟、多莢、小粒
2. KS 8	（高雄八號品種）	晚熟、高產、大粒
3. TNG 15	（臺農十五號品種）	中晚熟、中粒

1.臺灣省農業試驗所　研究報告第 1432 號。

2.本所農藝系助理與臺灣大學農藝系教授。臺灣省　臺中縣　霧峰鄉。

4. TNG 4（臺農四號品種） 中晚熟、中粒

（二）處理項目：

因爲大豆有限型品種於 R4 時期，無限型品種於 R5 時期去葉，可造成減產之極大值 (2,4,7) 而於 R7 時期以後處理，則對提早成熟期無顯著影響 (3,5)，故本試驗選定於 R6 時期（full seed）進行各項處理。又因巴拉刈常供爲大豆、棉花、及馬鈴薯等作物之落葉劑，且其使用效果佳，故爲本試驗所選用。

1.落葉劑處理 (1,10)；包含三種濃度之巴拉刈（paraquat）

1D：濃度爲 19ml/gal 或 19ml/3.785 l 之 paraquat

2D：濃度爲 38ml/gal 或 38ml/3.785 l 之 paraquat

3D：濃度爲 57ml/gal 或 57ml/3.785 l 之 paraquat

2.剪葉處理 (2,6)：

Upper：指剪除上半部葉片

Lower：指剪除下半部葉片

Whole：指剪除全部葉片

3.對照處理：（Check）

（三）試驗設計：

採用 RCBD，七個處理，兩個重複，單行區，行長 3 公尺，行株距爲55×15公分，每穴播種兩粒。

（四）調查性狀：

於收穫時記載成熟日期，同時調查倒伏度，取樣 5 株，置於日光下曝晒 2 ～ 3 天後，進行莢數、百粒重、子粒產量等性狀之調查。

1.成熟期：調查各小區自播種至90％以上植株莢果乾涸黃褐之天數。

2.產量：每小區取樣 5 株之子粒重。

3.莢數：每小區取樣 5 株之果莢數。

4.百粒重：每小區取樣 5 株混合種子100粒之重量。

5.品質：由種子外觀和充實度鑑別：

1 級：指充實不良或種皮皺縮子粒所占之比例小於 5 ％者。

2 級：指充實不良或種皮皺縮子粒所占比例介於 5 ％與20％之間者。

3 級：指充實不良或種皮皺縮子粒所占比例介於20％與40％之間者。

4 級：指充實不良或種皮皺縮子粒所占之比例大於40％者。

6.倒伏率：於收穫時記錄各小區倒伏植株所占之百分比。

（五）栽培與管理：本試驗於76年夏作在臺中農業試驗所試驗田進行，栽培管理方法仿照一般大豆栽培法。

結果與討論

由表一、顯示三種不同濃度落葉劑之使用，均可顯著達到提早成熟期之效果，三種濃度落葉劑施用於四個參試品系之平均效果分別爲；1D 可提早7.4天，2D 可提早8.6天，3D 可提早12.9天，顯示落葉劑使用效果大致隨濃度之增加而提高，就落葉劑對不同品種成熟期之提早效果而言，早熟之 M34—1品系（成熟期爲85天）可提早成熟期3.5～7.0天，中、晚熟之其他三品種（成熟期爲 97.5～100天）則可提早7.0～19.5天，可知使用落葉劑於中、晚熟品系以提早成熟期之效果大於早熟品系。

除了 TNG 15 品種剪去上半部葉片可顯著提早成熟期4.5天外，其他三品種（系）無論剪去上半部或下半部葉片，均未顯著達到提早成熟期之效果，但是剪去全部葉片時，則顯著提早成熟期，說

表一、落葉劑與剪葉處理對大豆成熟期及產量之影響

Table 1. Changes of maturity and yield of soybean when treated with paraquat and defoliation

Treatment	Change of maturity (days)					Change of yield (%)					Change of yield/ Change of maturity
	M34-1	KS 8	TNG15	TNG 4	Mean	M34-1	KS 8	TNG15	TNG 4	Mean	
Paraquat											
1D	− 4.0	− 9.5	− 9.0	− 7.0	− 7.4	− 28.8	− 56.5	− 45.4	− 37.5	− 42.0	5.7 (%/day)
2D	− 3.5	− 9.5	− 10.5	− 11.0	− 8.6	− 38.8	− 55.6	− 52.4	− 37.5	− 47.5	5.7
3D	− 7.0	− 11.5	− 13 5	− 19.5	− 12.9	− 57.6	− 46.7	− 56.4	− 51.5	− 53.1	3.3
Leaves cut off											
lower 1/2	0.0	− 2.0	− 1.5	0.0	− 0.9	− 13.0	− 36.0	− 26.7	− 27.9	− 25.9	
upper 1/2	− 1.0	− 3.5	− 4.5	− 3 5	− 3.1	− 48.0	− 41.8	− 52.0	− 55.4	− 49.3	
whole	− 3.0	− 7.0	− 10.0	− 10.0	− 7.5	− 45.5	− 50.0	− 58.9	− 55.0	− 52.4	7.0
L. S. D. (5%)	2.8	6.0	3.5	4.1		12.9	16.4	20.4	8.5		
C. K.	85.0	100.0	98.5	97.5		67.1	122.7	87.4	77.6		

明大豆上半部及下半部葉片共同影響成熟期，當剪除一半葉片時，剩餘葉片尚具緩衝能力，而未能顯著提早成熟期，又由於多數品種（系）剪去具有遮蔭作用之上半部葉片後仍未能顯著提早成熟期，推論葉片遮蔭作用並非影響大豆生育後期成熟期之主要因子。M34—1 品系剪去全部葉片可顯著提早成熟期3天，而其他三品系則可提早 7～10天，可知無論落葉劑或剪葉處理，均以中、晚熟品系較早熟品系有較佳提早成熟期之效果。

Whigham & Stoller [10] 指出於大豆成熟前 3～4 週噴灑 paraquat, glyphosate 及 amertryn 三種殺草劑，均可提早成熟期，但亦造成產量降低，而於成熟前兩週內處理則效果不顯著。Begum & Eden [2] 發現在開花期剪除⅓葉片，對於產量無顯著影響，但剪除全部葉片則使產量顯著降低。本試驗結果顯示，無論三種不同濃度落葉劑處理，或剪除上半部，下半部及全部葉片，均會造成產量顯著降低，1D, 2D 及 3D 落葉劑處理，造成減產百分率分別爲42.0%，47.5%及53.1%，除早熟品系 M34—1 產量隨落葉劑濃度之提高，其產量損失百分率愈大外，三種濃度落葉劑處理，造成產量損失百分率相近，可知對多數品系而言，1D 落葉劑濃度已造成嚴重產量損失。

就剪葉處理而言，剪除上半部或下半部葉片，已使產量顯著降低，可見於生育後期剪除下半部葉片，非但無顯著提早成熟期之效果，却造成約26%產量損失，另外剪除上半部葉片，造成約50%產量之損失，與剪除全部葉片造成52%產量之損失間無顯著差異，約爲剪除下半部葉片產量損失之一倍，顯示上半部新葉片對於產量之影響大於下半部老葉片。

若僅考慮產量及提早成熟期之得失，可由提早成熟期之天數及平均產量損失百分比，求得平均欲提早一天成熟期所造成產量之損失，以剪除全部葉片造成 7.0%之損失爲最大。落葉劑處理造成之損失小於剪除全部葉片者，三種濃度造成產量損失百分比分別爲：1D 5.9%, 2D 5.4%, 3D 4.1% 即較高濃度之落葉劑可獲較小之損失，以一般採用之 2D 濃度葉劑或剪除全部葉片處理而言，欲提早一週成熟期，則分別造成37.8%及49.0%產量損失，且因本省目前無早熟而高產之大豆推廣品種，足見選擇早熟而產量與推廣品種間無顯著差異之品種，已可達到消極增產效果，換言之，就要求早熟特殊環境需要而言，選育較現有推廣品種一高雄八號早熟七天以上，且產量未低於對照品種者，已符合栽培需要。

表二、落葉劑與剪葉處理對大豆莢數及百粒重之影響

Table 2. Changes of pod number and 100 seed weight of soybeans when treated with paraquat and defoliation

Treatment	Change of pod no. (%)					Change of 100 seeds wt. (%)				
	M34—1	KS 8	TNG 15	TNG 4	Mean	M34—1	KS 8	TNG 15	TNG 4	Mean
Paraquat										
1D	− 9.7	− 23.7	− 28.6	− 8.6	− 17.6	− 19.0	− 30.8	− 21.6	− 21.7	− 23.3
2D	− 16.7	− 22.6	− 24.1	− 13.7	− 19.3	− 24.9	− 30.0	− 28.7	− 26.2	− 27.5
3D	− 40.0	− 12.2	− 28.6	− 25.5	− 26.6	− 28.1	− 31.3	− 33.2	− 30.5	− 30.8
Leaves cut off										
lower 1/2	− 5.8	− 29.9	− 18.9	− 27.3	− 20.5	− 14.7	− 8.0	− 12.9	− 0.5	− 9.0
upper 1/2	− 31.9	− 20.2	− 34.4	− 40.4	− 31.7	− 20.7	− 23.8	− 22.2	− 18.7	− 21.4
whole	− 23.1	− 16.1	− 38.9	− 31.3	− 27.4	− 26.7	− 26.6	− 28.7	− 26.8	− 27.2
L. S. D. (5%)	10.1	22.4	22.0	11.3		5.4	10.1	10.5	16.4	
C. K.	90.9	57.9	57.6	45.1		7.4	23.4	16.1	18.2	

落葉劑及剪葉處理造成產量降低之可能原因有二；一為莢數降低，另為子粒充實不良以致百粒重降低所致，由表二得知除了 M34—1 及 TNG 4 品種（系）以 1D 濃度處理，M34—1 品系剪除下半部葉片與 KS 8 剪除上半部及全部葉片處理對莢數無顯著影響外，其他各濃度落葉劑及剪葉處理均造成莢數顯著降低，1D, 2D 及 3D。處理莢數降低百分率分別為 17.6%，19.3%，及 26.6%，而剪去下半部、上半部及全部葉片造成莢數降低百分率分別為20.5%、31.7%及27.4%，但因品種而異，除了剪去下半部葉片對 KS 8 及 TNG 4 兩品種百粒重無顯著影響外，其他各處理均造成百粒重顯著降低，其中 1D, 2D 及 3D 處理平均降低百分率分別為23.3%、27.5%及30.8%，大致隨濃度增高而加劇，而剪除上半部與全部葉片間無顯著差異（分別為21.4%及27.2%），但均遠大於剪除下半部葉片者（9.0%）。

剪除下半部葉片造成莢數顯著降低之品種（系）（KS 8 及 TNG 4）未顯著影響百粒重，顯著造成百粒重降低之品種（系）（M34—1 及 TNG 15）反而未顯著影響莢數，但剪除上半部或全部葉片均造成百粒重及莢數降低，推測於生育後期下半部葉片仍具供源（Source capacity），當去除下半部葉片時，導致供源能力不足，所以在莢數未顯著降低之品系，其上半部葉片所分配至各莢或子粒之乾物質則相對降低，因而造成百粒重顯著降低；在莢數顯著降低之品系，因其上半部葉之供源尚足以供給剩餘果莢或子粒充實之需要，故百粒重未顯著降低；但當剪除上半部或全部葉片時，供源嚴重不足，即使在莢數顯著降低情況下，亦無法充分供給子粒充實之需要，因此百粒重顯著降低。可知生育後期下半部葉片仍具供源能力，因為品種不同而造成落莢差異，影響子粒充實，其影響主要在於分配（Distribution），而上半部葉片則為主要供源，故當上半部葉片剪除時，形成嚴重供源不足，故使子粒充實不良，其影響主要在於供源強度（Source strength），推測落葉劑處理之影響亦趨向於供源強度之減弱，故造成多數品種（系）莢數及百粒重之降低。

Teigen & Vorst [8] 發現大豆剪葉及疏植均可降低倒伏度，且在 R3 去葉較 V7 時期去葉有較佳效果，Weber & Fehr [9] 提出由於倒伏造成機械採收之產量損失約占1.3%，且機械採收高度由離地面3.5吋提高至5.0及6.5吋時，則其產量損失由 5.4%增至9.4%及12.2%，而以木樁支持大豆植株

表三、落葉劑與剪葉處理對大豆倒伏率及種子品質之影響

Table 3. Average lodging and seed quality of soybeans when treated with paraquat and defoliation

Treatment	Lodging (%)				Seed quality (score)			
	M34—1	KS 8	TNG 15	TNG 4	M34—1	KS 8	TNG 15	TNG 4
Paraquat								
1D	0	0	0	10	1	2	2	2
2D	0	0	0	0	1	2	2	2
3D	0	0	0	0	2	3	3	2
Leaves cut off								
lower 1/2	0	0	10	25	1	1	1	1
upper 1/2	0	0	0	5	1	1	1	1
whole	0	0	0	0	1	2	1	2
C. K.	5	10	55	40	1	1	1	1

防止倒伏，可增產13%。Whighan & Stoller [10] 指出噴灑 Glyphosate 殺草劑以提早大豆成熟期，將使後裔種子發芽力及幼苗生長活力降低，使用 Glyphosate, Paraquat 及 Ametryn等殺草劑，均使種子油分百分率降低，蛋白質百分率增高，但 Begum & Eden [2] 則認為去葉處理對大豆品質無顯著影響，金 [1] 報告指出不同成熟度之大豆含有相同之 Trypsin inhibitor activity，而大豆總固形物含量及 7S 蛋白質／11S 蛋白質比值隨成熟度增加而增加。

本試驗結果（如表三），M34—1, KS 8, TNG 15 及 TNG 4 等四品種（系）之對照處理平均倒伏率分別為 5 %、10%、55%及40%，經由落葉劑或剪葉處理均使倒伏率降低，但亦造成種皮皺縮，種皮色澤暗淡，品質降低，且依落葉劑使用濃度之增加其影響愈大，可知落葉劑及剪葉處理，雖降低倒伏率，却也降低種子品質。

由本試驗得知，落葉劑及剪除全部葉片處理均可提早大豆成熟期，降低倒伏率，特別對中、晚熟品系較早熟品系有較佳處理效果，但相對造成產量損失及種子品質低落，其中產量嚴重損失，主要係因百粒重及莢數降低之雙重影響；就落葉劑使用濃度而言，隨濃度提高，提早成熟期及降低倒伏率之效果愈佳，產量無顯著差異，但種子品質變劣，另就剪葉處理而言，除 TNG 15 外，其他三參試品種（系）剪除上半部或下半部葉片均未能顯著提早成熟期，反而促使產量降低，剪除全部葉片之效果與落葉劑處理（2D）相當，又由剪除具有遮蔭效果之上半部葉片，未能顯著提早成熟期，顯示大豆生育後期葉片遮蔭作用並非決定成熟期之關鍵，而由剪除下半部葉片仍能影響大豆產量，可見生育後期下半部葉片仍對產量有貢獻。

姑且不計藥劑成本及噴藥或剪葉工資，評估欲以落葉劑（paraquat）或剪葉處理提早成熟期七天，已造成30%以上產量之損失，故除非為防患不時天然災害，否則落葉劑或去葉處理均不值採行，其根本之道乃在選育早熟而豐產品種。

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Influence of Paraquat and Defoliation on Maturity, Yield and Quality of Soybeans[1]

Shun-Fu Lin[2] and Cheng Chen[3]

Summary

To evaluate the relation between accerating harvest and yield reduction of soybeans, 3 concentrations of paraquat and 3 defoliation treatments (including cutting of upper 50%, lower 50% and whole leaves) were applied at R6 (full seed) growth stage. The results were summarized as following:

1. Paraquat and defoliation treatments could accerate harvest, but reduce yield and seed quality also.

2. There was no significant difference in yield reduction among 3 concentrations of paraquat treatments, however high concentration had better effects on accerating harvest and decreasing lodging.

3. Cutting of upper 50%, the main part causing the shading effects, and lower 50% leaves had no significant effect on accerating harvest, but on yield reduction, showing that shading was not the decisive factor for maturity at late growth stage of soybeans.

4. The result of enormous yield reduction by paraquat and defoliation treatments is caused from the decrease in pod number and 100 seed weight.

5. Evaluating between shorting 7 days to maturity and inducing more than 30% yield reduction, indicated that the treatments of paraquat and defoliation were not worth recommending.

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1. Contribution No. 1432 from the Taiwan Agricultural Research Institute.

2. Research assistant, Department of Agronomy, TARI, Wufeng 41301, Taiwan, R. O. C.

3. Professor, National Taiwan University, Taipei , Taiwan, R. O. C.

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不同海拔地區對三島柴胡 (*Bupleurum falcatum* L.) 生育性狀、產量及有效成分saponin含量之影響[1]

劉 新 裕[2]

摘要 進行三島柴胡育苗工作時，先篩取較大粒種子，經4－6星期低溫層育處理後再播種，將有助於在較短時間內達到較高的發芽效果。

於中海拔地區如春陽栽培柴胡，經一年、一年半及二年後根之收量爲高海拔梅峰柴胡之1.27、1.13及1.45倍。

75%之遮蔭效果不佳，已顯著影響除了株高外柴胡其他性狀之表現，遮蔭柴胡之根重只爲對照柴胡之42%；早植因能延長柴胡之營養生長，較有利於根部生長發育與貯藏養份，且以二月種植者較佳。

梅峰試區之土質較粘，柴胡根部之發育以支（鬚）根爲主，主根只佔全根重之23%，由於支（鬚）根內含較多 crude saponin，所以梅峰柴胡之根收量雖低於春陽，但saponin產量則較高，春陽柴胡根部脂質含量則顯著高於梅峰者。

梅峰及春陽柴胡地下部位根內元素含量一般高於其地上莖葉，而比較兩處柴胡根內元素含量，春陽在Mg、Na、K及P含量上依序爲梅峰之2.0、2.1、1.4及1.2倍，而梅峰則在Ca、Mn及Zn含量上爲春陽之1.1、2.0及1.5倍。

柴胡爲我國傳統醫藥中極爲重要的藥用植物之一，根爲主要藥用部位，神農本草經列爲草部上品，其藥性苦、平、無毒，主治胸脅苦滿及其他肝膽疾病等症 (1,3,9,15) ，另有消炎、解熱、鎮靜、鎮痙、鎮痛及抗過敏等作用，久服能推陳致新、輕身明目及益精 (14) 。本省每年需要量極大，惟大多仰賴進口，據國貿局海關73年資料指出，柴胡進口量爲67,941kg，共耗外匯達 15,200,000 元。省產三島柴胡 (*Bupleurum falcatum* L.) 之品質爲各種柴胡之最佳者 (14,15) ，且其療效與保肝作用已由國內醫藥單位證實比進口大陸產柴胡品種優異 (4,5) ，值得大量栽培開發。

三島柴胡爲繖形科 (*Umbelliferae*) 多年生植物，一年生之株高可達 80cm 以上，第一年莖一般爲單一莖，翌年可生新莖4－6支，葉具平行脈，廣線形或細披針狀，互生，由著生部位不同可分爲根生葉及莖生葉，兩種皆無柄但有短鞘，花多數、小而色黃，爲複繖形花序，一般花期爲5—11月，果實長橢圓形，褐色無毛，每一繖形花可生出約12粒果實，內各含2粒種子，一般之果期爲7—12月，根可分成三類，即主根、支根及鬚根，三者間之比例將依產地土質與栽培管理 (2) 而異。

三島柴胡於本省之栽培年代甚短，且栽培方法多仿效日本，然而因日本之低溫期較長使一般之栽培未臻十分成功，其根較細長且栽培2－3年後才能採收 (18) 。依據農試所初步研究結果可知，三島柴胡於平地、中海拔及高海拔地區都能生長，顯示其適應能力相當大，惟中海拔地區根的收量較高；於採種育苗時，柴胡種子以開花後60—70天左右者較宜 (6) ；採種後之儲藏方式以儲放於定溫箱、玻璃乾燥器或冰箱中較能保持種子活力 (6) ，另外，利用低溫層育 (0—4°C) 或日夜溫差達8—12°C處理種子，可以提高柴胡種子之發芽率及增進發芽勢 (10,11) ，而有助於育苗不整齊問題之克服，其發芽之較適溫度爲 16°C，種子育苗後再移植本田，爲現行栽培方式，其行株距一般爲30×20cm或20×20cm，一般採收適期爲一年半左右 (2) ，採收後乾根即供生藥用途，且以氣味濃郁、根質柔軟且色澤濃厚者爲優品。

1.臺灣省農業試驗所 研究報告第1433號。
2.本所農藝系副研究員。臺灣省 臺中縣 霧峰鄉。

本省有關三島柴胡的栽培資料不多，而栽培與品質之相關分析更須加强，本研究擬先就低溫層育與柴胡發芽與育苗之關係進行探討，其次將就兩處不同海拔地區栽培柴胡兩年的結果，就其農藝性狀表現及品質進行比較分析，在品質方面將側重柴胡主要藥效成分即柴胡皂苷配醣體（saponin）之測定與比較，另外試圖以其他營養成分如脂肪、維生素C及多種礦物元素含量來輔助說明三島柴胡之優異藥效作用。

材料與方法

一、試驗材料：三島柴胡（*Bupleurum falcatum* L.）之種子及種苗。

二、試驗方法：（1）低溫層育時期對柴胡發芽之影響：柴胡種子先以篩網依大小分成三級，即14、18及20 mesh，其千粒重依次爲1.68、1.23及0.61g，每級種子分別經1%次氯酸鈉（NaHClO）浸種消毒10分鐘，再以蒸餾水清洗並浸泡10分鐘後，置於上覆一層Whatman No. 1長型濾紙之壓克力發芽床上（床高3cm），並一起放入直徑15cm培養皿中，培養皿內添加二次蒸餾水約120ml，復加蓋以保持濕度。此三級柴胡種子連同培養皿放入冰箱內（0—4°C），進行十星期低溫層育處理（Cold Stratification），層育期間每星期固定取出種子，藉上述培養皿及濾紙等進行發芽試驗，發芽試驗分兩組進行，一組放在室溫中（二月），另一組放於 16°C 定溫箱中，每處理4重複，每重複30粒種子，每日檢視並登記發芽種子數目，發芽以胚根突出種皮爲準，二星期後統計其發芽率並計算到達總發芽率半數時間（Gt50）。（2）柴胡種苗之培育與定植：以千粒重1.23g以上之較大粒柴胡種子經四星期低溫層育處理後，取出播於整平之砂壤土苗床上，上覆稻草並充份澆水以防土壤乾燥且促其發芽，播種時期爲民國74年10月。以種子播種育苗後，再移植本田爲現行之栽培方法，移植法所需之勞力及時間較多且有傷根之可能是其缺點，但另方面則可以選取健株於較適當時期與地點以一定株距定植之，將使植株生長較爲整齊良好，亦將較有利於根部收量之提高，定植本田之行株距爲 30×20cm ，小區面積爲 $16m^2$，4重複，移植適期約爲根長5至6cm時，或有於定植前先經假植於塑膠杯中者，待植株健壯成長時再定植本田中，如此將更能確保定植後之高成活率，本試驗之假植時間爲75年元月，定植時間爲75年2—3月。（3）田間管理：柴胡初期生長緩慢，應充份供給水份、養份及清除雜草，中耕宜淺並適時加施肥料，基肥以每分地 500公斤雞糞爲主，每2個月混合使用臺肥5號每株3克及有機肥料作爲追肥，於開花時期應施行摘心，即將花序全部摘除，若任其開花將影響根之發育與收量，此外並應注意病蟲害防治工作。（4）不同海拔栽培試驗：柴胡種苗假植3—4星期後，選擇健株定植於臺大山地農場兩處不同海拔之試驗站，一處爲2,200m之梅峰農場，另一處爲1,200m之春陽農場，因兩地之溫度及土宜殊異，梅峰之溫度較低（年平均溫度13.2°C），約低春陽6°C，且土質較粘（兩地同屬砂礫地），此將對柴胡之生長性狀及品質造成不同的影響。於假植及定植柴胡後第2、6、12、18及24個月，調查株高、株重、分蘖數、莖徑、根長、根徑、根重及總分枝數等性狀。（5）遮蔭試驗：於梅峰試區同時進行75%遮光網遮蔭試驗以探討對其生長發育之影響。（6）早植試驗：於76年元月起在春陽地區另外進行第二批假植苗於間隔一個月時分成四期定植本田，以探討提早定植對於柴胡生長發育之影響，調查項目爲株高、全部分枝數、最大葉之葉長與葉寬、根之性狀及產量等。以上各處理之調查株數爲隨機取樣20株，於水洗後陰乾 36hrs調查，並以結果平均值表之。（7）根部成分分析：水分以普通常壓乾燥法定量。脂肪乃利用 Soxhlet裝備以石油醚萃取求得之粗脂肪質表之。礦物元素含量測定乃取1g樣品以三酸混合液（即HNO_3：$HClO_4$：H_2SO_4以4：1：1（v/v）的比率混合）加熱分解或1N HCl靜置24hrs並定量至50ml後，以焰光分析法分析K與Na，以原子吸光法測Ca、Mg、Fe、Mn、Cu及Zn, P 則以鉬黃法分析。維生素C分析：利用Dichloroindophenol滴定法定量。柴胡皂苷配醣體（saponin）測定：柴胡粗粉以甲醇回流萃取及減壓濃縮後，利用正丁醇與水進行兩相溶劑萃取，之後回收丁醇，其殘留物再以乙醚回流約半小時後過濾烘乾及稱重，乙醚之不溶物即爲 saponin含量[16]，上述分析過程中，每處理隨機取樣烘乾樣品2—5克，3—4重複，分析後再以平均值表示之，同時進行變方分析及比較差異之顯着性。

結 果

爲期順利進行三島柴胡育苗及栽培工作，提高其種子之發芽率及發芽勢應爲當務之急。不同大小柴胡種子在歷經1至10個星期低溫層育處理後，在一及二月室溫下或 16°C 定溫箱中之發芽率呈現兩種不同的趨勢，較大粒柴胡種子（14或18 mesh）於第四或第六星期達到發芽高峰之後，即呈逐漸下降現象，而較小粒柴胡種子（20mesh）之發芽率於最初幾個星期偏低，但到第七或八星期時却有大幅提升的趨勢（表1）。三類種子大小及除了第十星期層育種子外，在元月及二月室溫下之發芽結果都高於16°C 之定溫箱者，且愈大粒種子之發芽率愈高。在年初環境下進行育苗工作時，所需之層育時間由表1可知爲2至8星期，而在16°C定溫環境下則爲4或8星期。層育時間愈長時，所需 Gt50 之時間愈短，以8星期層育種子爲例，在室溫中發芽Gt50爲5天，在 16°C定溫中爲9天，而不經層育之對照種子則需19天才到達Gt50.

Table 1. Effects of seed size and stratification treatment on germination of *Bupleurum falcatum* L.

Seed size (mesh)	Duration of cold stratification (wk) 2	4	6	8	10	mean
Germination (%) at room temperature in Feb. 1988						
14	66.5	66.8	57.5	62.8	36.8	58.1[a]*
18	51.8	56.0	68.5	59.0	37.8	54.6[a]
20	41.5	42.8	50.8	58.3	30.8	44.8[b]
mean	53.2[a]	55.2[a]	58.9[a]	60.0[a]	35.1[b]	52.5
Germination (%) at 16°C						
14	43.0	59.3	33.3	45.0	41.5	44.8[a]
18	40.7	59.8	31.0	42.5	36.8	42.5[a]
20	35.6	41.8	9.3	59.3	36.8	33.6[b]
mean	39.8[b]	49.4[a]	24.5[c]	48.9[a]	38.3[b]	40.3

*Means followed by the same letter within line and column are not significantly different at 5% level by Duncan's New Multiple Range Test.

於不同海拔地區定植栽培三島柴胡，不論是在春陽地區（1,200m）或梅峰地區（2,200m）其生育狀況都很好，病蟲爲害甚少。各別比較三島柴胡在連續24個月之農藝性狀及產量可知，在春陽地區第一年（老莖）株高達 87.9cm，第二年（新莖）略爲增高，兩者差異未達顯著水準；第二年之株重明顯高於第一年者，增重達80%；在分蘖、莖徑及總分枝數三方面第二年之數值分別比第一年增加0.4、0.6及 0.5倍；比較根部三項性狀都以第24個月者爲優，以其中根之乾重量爲例，則分別超出第18個月及第12個月達36%及52%。在梅峰地區之第一年株高只約爲第二年之76%，兩者差異明顯；第二年之株重比第一年約增加0.73倍；在分蘖、莖徑及總分枝數三方面，第二年者分別比第一年增加0.6、0.2及 1.1倍；比較根部三種性狀，亦以第二年者較優，惟增加幅度略緩於春陽者，以根乾重爲例，二年生者分別爲一年半及一年生者之106%及133倍。綜合比較兩地兩年之栽培結果得知，春陽柴胡雖在株高、分蘖及根長三方面不如梅峰柴胡，但在株重、莖徑、根徑、總分枝數及根重五方面都較

梅峰為優，詳細比較兩地12、18及24個月柴胡根之收量，春陽分別為梅峰之1.27、1.13及1.45倍高（表2）。

Table 2. Growth characteristics and yield of *B. falcatum* plants after various durations of cultivation at two different elevations

Culture duration (month)	Plant height (cm)	Plant weight (g)	Tillers (no..)	Total branches (no.)	Stem diameter (cm)	Root length (cm)	Root diameter (cm)	Root weight (g. d. w.)	Estimated yield (kg/ha)
Tsun-yang (1200m)									
2	18.30 c*	2.41 c	1.00 b	1.5 c	0.38 b	12.75 c	0.26 d	0.28 c	45 c
6	78.40 b	43.37 b	1.00 b	121.0 b	0.46 b	14.04 bc	0.72 c	2.31 c	370 c
12	87.90 ab	47.70 b	2.70 a	169.0 b	0.50 b	15.94 bc	1.12 bc	8.25 b	1,320 b
18	92.30 ab	81.38 a	3.54 a	245.0 a	0.52 b	16.38 b	1.34 b	9.22 b	1,475 b
24	96.15 a	86.24 a	3.70 a	261.7 a	0.79 a	20.02 a	1.82 a	12.54 a	2,006 a
Mei-fung (2200m)									
2	18.30 d	2.41 e	1.00 c	1.5 d	0.38 a	12.75 c	0.26 d	0.28 d	45 d
6	60.12 c	32.48 d	1.00 c	37.0 c	0.40 a	15.21 bc	0.61 c	2.16 c	346 c
12	83.04 b	48.95 c	2.42 b	54.2 c	0.44 a	17.59 ab	0.89 b	6.51 b	1,042 b
18	94.02 ab	69.20 b	3.20 ab	95.5 b	0.49 a	20.41 a	1.05 b	8.14 a	1,302 a
24	109.73 a	84.72 a	3.79 a	116.3 a	0.51 a	20.52 a	1.35 a	8.65 a	1,384 a

*Means followed by the same letter within each column are not significantly different at 5% level by Duncan's New Multiple Range Test.

定植於梅峰試區75%遮光環境下，一年半生柴胡之株高平均約超出對照植株 10cm左右，惟差異未達顯著水準，至於其他性狀的表現都較對照組不遮光植株為差，其中尤以株重、分蘗數、總分枝數及根重為然，比較上述四項性狀兩者之差異，遮蔭柴胡只為光照柴胡之38、55、24及42%（表3），有了這些負面影響，將很不利於生產柴胡。

由春陽地區三島柴胡早植試驗結果可知，愈早定植柴胡將較有利於初期植株之生長發育，對於株高及總分枝數之發展更具顯著效果，最早定植之株高分別比相隔1、2及4個月晚植者高出40、69及170%，總分枝數亦多出達1.40、1.42及10.24倍（表4），由柴胡多項農藝性狀與其根產量之關係可知（表6），影響根收量之相關因素甚多，株高即為其中影響較顯著因素之一，所以愈早於中海拔地區如春陽種植柴胡將較有利於生長、發育或增高產量。

經18個月生育期後，一月及二月定植之柴胡除了分蘗數、莖徑及根長三項性狀較三月定植者略低外，其餘之性狀如株高、株重、根徑及根重都優於後者，比三月更晚一個月（四月）種植之柴胡各項性狀及產量表現更差（表5），由此可知早植確能提高柴胡之生長勢及產量，而且以二月定植之效果最佳。

Table 3. Effect of shading on the growth characteristics of *B. falcatum* at Mei-fung station (2,200m.)*

Treatment	Plant height (cm)	Plant weight (g)	Tillers (no.)	Total branches (no.)	Stem diameter (cm)	Root length (cm)	Root diameter (cm)	Root weight (g.d.w.)
Shading	119.8 a**	18.5 b	2.20 b	23.0 b	0.33 a	12.04 b	0.83 a	3.54 b
Control	109.7 a	48.5 a	3.99 a	95.5 a	0.51 a	20.61 a	1.15 a	8.41 a

*After 18 months of culture duration.
**Means followed by the same letter within each column are not significantly different at 5% level by Duncan's New Multiple Range Test.

Table 4. Effect of earlier planting on the growth characteristics of *B. falcatum* plants at early growth stage.

Planting (1987)	Culture duration (month)	Plant height (cm)	Total branches (no.)	Leaf length (cm)	Leaf width (cm)
Jan.	5	45.13 a*	14.33 a	15.40 a	1.51 a
Feb.	4	32.13 b	10.27 b	14.93 a	1.64 a
Mar. (CK)	3	26.63 b	10.07 b	15.23 a	1.37 a
April	1	16.70 c	1.40 c	12.20 b	0.84 b

*Means followed by the same letter within columns are not significantly different ($p \leqq 0.05$), using Duncan's New Multiple Range Test.

Table 5. Effect of earlier planting on the growth characteristics and yield of *B. falcatum*

Planting date (1987)	Culture duration (Month)	Plant height (cm)	Plant weight (g)	Tiller (no.)	Stem diameter (cm)	Root length (cm)	Root diameter (cm)	Root weight (g. d. w.)	Yield (kg/ha)
Jan.	18	93.4a	59.4a	3.0a	0.60a	14.1b	1.46b	10.8a	1,804a
Feb.	18	102.7a	62.7a	3.2a	0.64a	15.3a	1.68a	11.3a	1,887a
Mar. (KC)	18	97.9a	58.6a	3.6a	0.67a	15.8a	1.43b	9.6b	1,603b
April	18	81.5b	52.8a	2.9a	0.56a	14.2b	1.40b	8.8b	1,470c

Means followed by the same letter within columns are not significantly different ($P \leqq 0.05$), using Duncan's New Multiple Range Test.

Table 6. Correlation coefficients of the agronomical characteristics and yield of *B. falcatum* L.

Characteristics	Plant height (cm)	Plant weight (g)	Tillers (no.)	Total branches (no.)	Stem diameter (cm)	Root length (cm)	Root diameter (cm)	Root weight (g.d.w.)	Estimated yield (kg/ha)
Plant height		0.94**	0.82**	0.72*	− 0.91**	0.96**	0.87**	0.81**	0.86**
Plant weight			0.91**	0.81**	− 0.79**	0.90**	0.94**	0.89**	0.92**
Tillers				0.74*	− 0.57	0.74*	0.91**	0.96**	0.95**
Stem diameter					− 0.61	0.63*	0.89**	0.84**	0.84**
Total branches						− 0.95**	− 0.70*	− 0.60	− 0.68*
Root length							0.82**	0.75*	0.81**
Root diameter								0.96**	0.97**
Root weight									0.99**
Estimated yield									

*, ** : Significant at the 0.05 and 0.01 probability levels, respectively.

柴胡之藥用部位爲根，產地地質、氣候、栽培時間及栽培管理等因素對於柴胡根之生長結果影響很大，由表2及表3可知，春陽柴胡根之收量高於梅峰不少，而光照區者又顯著重於遮蔭柴胡。春陽試區柴胡主根及支根（含鬚根）之比例依採收時間差異頗大，一年生、一年半及二年生柴胡之主根佔全根比重分別爲79%、60%及43%，呈依次遞減，支根之比重則反之，依次爲21%、40%及57%，呈逐漸上升，梅峰試區二年生柴胡主根之比重甚且降至23%，根收量中有77%是屬於支根及鬚根。由於部位之不同將影響柴胡之主要成份含量。Crude saponin爲柴胡的有效成分，它是數種saikosides之混合物[11]，以二年生柴胡主根爲例，其 crude saponin 含量平均約爲1.0%，比支根（含鬚根）之1.77%減少，因爲梅峰柴胡根部以支根爲主，且約爲主根之3.3倍量，比春陽柴胡支／主根之1.3倍超出不少，所以梅峰柴胡根收量雖少，但其 saponin產量却與春陽相近（表7）。脂質爲柴胡根部另一重要成分[15]，由表中可知，春陽柴胡根部脂質及維生素 C 含量顯著高出梅峰柴胡，至於含水率方面則反之，以梅峰柴胡爲高。

Table 7. Comparison on the concentrations of four chemical compositions of *B. falcatum* roots grown at two different elevations

Location	H_2O (%)	Fat (%)	Vit. C (ms/100g.d.w)	Saponin Conc. (%)	Saponin Yield (kg/ha)
Tsun-yang	47.59 ^{a*}	5.94 ^{a}	4.00 ^{a}	1.05 ^{b}	21.1^{a}
Mei-fung	48.96 ^{a}	4.23 ^{b}	2.86 ^{b}	1.56 ^{a}	21.6^{a}

*Means followed by the same letter within each column are not significantly different at 5% level by Duncan's New Multiple Range Test.

比較不同海拔地區二年生柴胡植株元素含量之差異可知，在九種元素中，地下部位根中之數量一般多於其地上莖葉，以梅峰爲例，其莖葉之 Ca、Mg、Na、Fe四項元素含量顯著高於其根，但在K、P、Mn、Zn及Cu五項元素含量則顯著較低，此種情形在春陽柴胡更爲明顯，其莖葉只在 Ca及Mg二項元素含量上高於其根，其他七種元素含量都顯著低於根。比較兩地柴胡根元素之差異，春陽柴胡

Table 8. Comparison on the concentrations (mg/100g. d. w.) of some essential elements in different plant parts of *B. falcatum* grown at two elevations.

Part	Ca	Mg	Na	K	P	Fe	Mn	Zn	Cu
Tsun-yang (1,200m)									
Root	84.3^{b*}	2.0^{b}	62.3^{a}	1,141.0^{a}	2,379.7^{a}	24.3^{a}	4.0^{a}	13.7^{a}	1.1^{a}
Stem & leaves	176.7^{a}	3.2^{a}	25.7^{b}	988.0^{b}	1,023.5^{b}	16.3^{b}	1.7^{b}	5.3^{b}	0.9^{b}
Mei-fung (2,200m)									
Root	95.3^{b}	1.0^{b}	29.7^{b}	809.0^{a}	2,040.7^{a}	21.7^{b}	8.1^{a}	21.0^{a}	1.2^{a}
Stem & leaves	129.0^{a}	2.2^{a}	35.3^{a}	720.7^{b}	1,617.3^{b}	61.7^{a}	5.1^{b}	13.0^{b}	0.8^{b}

*Means followed by the same letter within each column are not significantly different at 5% level by Duncan's New Multiple Range Test.

根在 Mg、Na、K 及 P 含量上優於梅峰柴胡，依序爲後者之2.0、2.1、1.4及1.2倍，而梅峰柴胡在Ca、Mn及Zn含量上顯著高於春陽者，且依序爲後者之 1.1、2.0及1.5倍，另外二種元素 Fe及Cu之含量差異不顯著（表7）。

討　論

以一般未經處理的柴胡種子進行育苗，將有發芽率較低且發芽過程較長的困擾，以三島柴胡種子爲例，在一般情形下之發芽率只有20—45%[7,11]，其發芽率只少數偶有高達80%者，且整個發芽過程需時近兩個月[11]，低溫層育處理能提高種子發芽率[8,20]，三島柴胡發芽率可提高到87%，一般可達60—70%，而且另有縮短發芽時間到只需2—3星期左右與提高發芽勢（Gt50）[19] 的優點，利用浸種處理或變溫處理亦有類似的優點[9]，較小粒柴胡種子內胚之發育較弱於大粒者，藉人工低溫層育輔助，種胚得能繼續分化並完成後熟作用，此即小粒種子在較長的低溫層育處理後，如八星期層育處理，能較大幅度提升其發芽率的可能原因之一。而柴胡一般之播種適期爲秋末冬初至冬末春初[2]，除了因其發芽適溫爲 16°C 外，此時期因有自然低溫及較穩定濕度之效，亦將有助於內生荷爾蒙之平衡[12] 及種胚之後熟與發芽，本次發芽試驗日期爲77年元月底至二月間有明顯的低溫及變溫關係，所以三種大小柴胡種子在室溫中比在16°C定溫箱中有較高的發芽率。

柴胡屬（*Bupleurum* L.）爲繖形科植物，全屬約有 100種以上，大抵分佈於北半球，本省自產一種，分佈於新竹及苗栗一帶山上，此即爲高氏柴胡（*B. kao* Liu Chao et Chuang），其與三島柴胡最大的區別點在於染色體數目，高氏柴胡之染色體數目爲2n＝12，此顯與三島柴胡染色體2n＝16不同，此外高氏柴胡根部脂管亦大於三島柴胡。高氏柴胡爲本省自生植物，在適應上强於日本引進之三島柴胡，其種子發芽率在不經處理下即高達79%即爲其中一例[7]。高氏柴胡與三島柴胡之品質及藥效都較大陸產北柴胡有過之而無不及[4,5,7]，此二種重要植物更詳盡深入之栽培比較，很值得加强進行。

柴胡植株全生育期之生長情形依海拔之提高而略有變異，第一年生植株於擴展根生葉後，於3—4月間抽苔並生長莖生葉，於五月起開始進行生殖生長，植株生長衆多腋生或頂生之複繖形花序，中海拔花期可延續至11—12月，較高海拔者如梅峰柴胡，開花有至翌年1—2月者，果期亦延至翌年二月左右。入多後植株地上部漸形褐化枯萎，第二年起再由根部萌發新芽並生長新莖約4—6支。梅峰柴胡於冬季低溫下，植株地上部紫紅化相當明顯，之後枯萎，亦於溫度逐漸上升時萌發新芽且長出新莖。以表2根之產量估算柴胡採收適期，梅峰柴胡於第一年內之產量已達1000kg/ha以上，其與第18及24個月者比較，有明顯產量差異現象，而一年半及二年生柴胡即無顯著差別，所以其採收適期應可決定爲生長達第12個月時或第18個月。而春陽柴胡於第一年及一年半生之產量差異並不顯著，二年生之產量則明顯高於其他生長時期，所以於中海拔如春陽栽培柴胡時，其採收適期應爲12或24個月而非一年半。是否因梅峰地區之溫度較低且土質較粘而能於一年或一年半採收，值得進一步就溫度與土質對柴胡之影響進行探討。

柴胡根部單獨使用時有下列多項藥效：主治胸脅苦滿且有抗炎症及抗過敏作用，此外另有鎮靜、鎮痙、鎮痛及鎮嘔之功能。柴胡根與其他生藥配伍時，將有相輔相成以增强某種功能之作用，如與黃芩（*Scutellaria baicalensis* George）配伍時能加强抗炎及解熱功能，與芍藥(*Paeonia lactiflora* Pallas）配伍時，對鎮靜、鎮痙及鎮痛等顯出增强作用，與甘草（*Glycyrrhiza uralensis* Fischer）配伍時能大幅減輕急迫性疼痛、痙攣與興奮現象[14]。上述諸項藥效主要根源於根內之主要成分Saponin，由表7可知，本試驗柴胡根中 Saponin之平均含量達1.30%，較日本栽培結果（0.5%）高出不少[15]，而比較兩地saponin含量亦以梅峰柴胡較高，除了已知梅峰柴胡由於支（鬚）／主根比率偏高致使saponin含量增高外，溫度[17]與土質是否對 saponin含量有影響也值得進行深入探討。柴胡根中其他重要成分如脂肪含量亦較日本產者爲高[15]，而根中維生素C含量則偏低。

臺灣金線連（*Anoectochilus formosanus* Hayata)與三島柴胡同爲本所進行藥用植物研究的兩

個重點植物，前者自生於本省，爲本省民間藥材代表植物之一，而後者一直爲我國傳統醫藥的重要植物，比較兩者根內元素之含量差異，臺灣金線連在 Mg、Na、Fe、Mn、Zn及Cu 含量上較優於三島柴胡[13]，但三島柴胡根中P之含量約爲臺灣金線連之 2.43倍（梅峰柴胡）及2.83倍（春陽柴胡），春陽柴胡根中另一種元素 K之含量亦爲臺灣金線連之3.62倍，三島柴胡根中這兩種元素由於含量甚豐，將對人體內神經之功能或有所俾益作用。

結　論

0—4°C 低溫層育處理能增强繖形科植物如三島柴胡之發芽率及發芽勢而有利於育苗工作。於中及高海拔栽培三島柴胡時，第一年根的收量已達 1,000 kg/ha，而最佳之採收期須視溫度高低與土質鬆粘程度而定，此亦能影響 saponin 含量。遮蔭75%處理甚不利於柴胡之生產，但早植應較有利植株之生長發育，且以二月定植較宜。

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Effects of two Different Elevations on the Growth Characteristics, Yield and Saponin Content of *Bupleurum falcatum* L.[1]

S. Y. Liu[2]

Summary

This study evaluated the influence of two different elevations, i. e. Tsun-yang station of 1,200m and Mei-fung station of 2,200m, on the agronomical characteristics, yield and the saponin content of *B. falcatum*, which is a very important and widely used medicinal herb.

Cold stratification of seeds at 0—4°C for 4 to 6 weeks significantly enhanced the germination rate and shortened germination time of the plant and was useful for seedling production. The results after two years of cultivation showed that root yield of *B. falcatum* after one, one and half and two years of planting at Tsun-yang area were 27%、13% and 50% higher than those of Mei-fung station, respectively. The yield data from two elevations also suggest that an optimal harvest time for *B. falcatum* would be those after one or two years of cultivation, depending on the cultivationsites.

75% shading significantly damaged the development of all agronomical characteristics except plant height. The root weight of the shaded plants was only 42% of that of the check. Earlier planting benefited from a longer vegetation period and caused vigorous growth.

Due to the heavier soil texture in Mei-fung plots, plants developed more adventitious roots and consequently higher crude saponin content in root than those grown in Tsun-yang. However, the fat content of root was found significantly higher in Tsun-yang than that in Mei-fung.

Contents of nine mineral elements were generally higher in root than in aboveground parts such as stems and leaves at these two altitudes. The concentrations of Mg、Na、K and P elements in root from Tsun-yang plants were 100% 、110% 、40% and 20% higher than those from Mei-fung, respectively, however, the contents of Ca, Mn and Zn were higher in Mei-fung plants than those at Tsun-yang station.

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1. Contribution No. 1433 from Taiwam Agricuultral Research Institute.
2.Agronomist, Department of Agronomy, TARI, Wufeng, Taichung Hsien, Taiwan 41301, ROC.

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低海拔桃品種改良初報[1]

溫英杰[2] 徐信次[2] 林學正[2] 呂明雄[3] 蔣明南[4]

摘要 爲改善本省低海拔桃之品質，陸續自世界各地引進桃種源試種，至76年度調查之資料顯示共有水蜜桃22種，油桃 5 種，蟠桃 1 種，罐桃 1 種，在平地可開花結實，其品質較本省低海拔栽培品種爲優，而遜於高冷地品種。

利用超高密度種植實生苗，經過一年半後由 814 株自然授粉而來之實生後代中選出 1 — 20等 8 個果大，風味佳之品系。控制授粉分 3 個途徑進行：(1)將本省在來品種與品質優良但高需冷性的高海拔水蜜桃品種互相雜交。(2)將低需冷性桃品種與高海拔之水蜜桃品種互相雜交。(3)將引入之低需冷性水蜜桃品種互相雜交。至76年度爲止初選出 5 — 9 等 3 個優良品系繼續作進一步之觀察。

以本省在來品種及引進試種成功之桃品種和高海拔種植之水蜜桃雜交，有些組合胚退化情形嚴重，無法獲得雜交後代，以胚培養雜交胚，結果以低海拔桃品種爲母本時，自授粉後第50天起，即可將胚置於 MS 培養基中培養成苗。以高海拔桃品種爲母本時，亦可在果實硬熟期時，將胚取出培養於 MS 培養基中，置 5°C中 4 個後，再移到日溫 25°C、夜溫21°C之環境培養成苗。

高、低海拔花期不同，以高海拔品種爲父本時，花粉需經長期貯存，以眞空低溫（—20°C）貯藏花粉 10 個月後，依品種不同，發芽率自50%～90%，較不抽眞空之對照組提高40%。

桃是我國原生的果樹之一，已有四千年的栽培歷史。在我國西北高原的山野地帶，都有野生桃的天然分佈。詩經魏風中有「園有桃，其實之淆」之句，詩經的出現約在西元前十世紀左右，魏風中所指之地即爲今日黃河以北以及山西等廣大的地區，園中植桃，爲有規模之生產，一般認爲在距今三千年以前的黃河流域已有桃的經濟栽培了。桃隨著通商活動的頻繁而傳至世界各地，至今，世界上主要的經濟生產品種，幾乎都有中國桃的血統。

在我們遼濶的土地上，各地都有其特別優秀的品種，如山東肥桃、上海水蜜、深州水蜜、奉化玉露、渭南甜桃、瀘定香桃等，信手拈來，不勝枚舉。本省桃品種據舊縣政誌觀之，最早似隨先民由廣東、福建傳入，品種有鶯歌桃、伯桃、雞慶桃、烏枝桃等。民國元年統計之資料顯示，當年全省桃的栽培面積僅有37公頃，臺灣光復時亦僅 176公頃，此後隨著社會的日趨繁榮，栽培面積逐年增加，民國50年全省栽培面積達308公頃，74年已達1,830公頃，值得注意的是，桃栽培面積之增加，主要是得力於橫貫公路開通後引進在高海拔地區種植之水蜜桃栽培面積之增加，依據山地農牧局統計之資料，民國72年本省高海拔水蜜桃栽培面積共480公頃，中海拔在來品種的栽培面積只有807公頃，較梨、葡

1.臺灣省農業試驗所　研究報告第 1434 號。本研究承行政院農業委員會補助及國科會研究成果獎助，謹誌謝忱。
2.本所園藝系助理、嘉義分所園藝系主任、本所園藝系前研究員兼主任現任臺南區農業改良場場長。臺灣省　臺中縣　霧峰鄉。
3.國立嘉義農專教務主任。
4.國立臺灣大學園藝系教授。

萄等果樹其在30年間增加之面積可謂甚少（表一）。

表一 本省中、低海拔幾種主要落葉果樹三十年來收獲面積之變化*(1)

Table 1. The harvested area of major deciduous fruit trees in the middle-and lowland of Taiwan in 1953 and 1983

種類	年度收穫面積 (ha)	
	42 年	72 年
葡萄	19	3,899
桃	245	807
李	1,087	2,440
枇杷	—	2,037
梅	340	4,404
橫山梨	54**	7,798
柿	314	786

*資料來源：山地農牧局統計年報及臺灣農業年報。
**民國44年種植面積。

中、低海拔桃產業未能大幅增長的原因在於：

（1）本省在來品種，果肉硬脆、甜度不高、果形亦不佳、商品價值不高。

（2）在來品種不耐貯存，又因其生產期均集中在端午節前後，恰爲梅雨季節，不但影響果實品質及甜度，且常造成果實腐敗，農家缺乏種植興趣。

（3）本省中、低海拔冬季低溫不足，無法栽培品質優良的高冷地水蜜桃品種。

另一方面，本省高山地區自中部橫貫公路開通以來，開始由日本引進水蜜桃品種栽培於梨山地區，依據山地農牧局由各有關鄉鎮提報之統計資料顯示，民國51年栽培面積僅15公頃，到了71年已經到達447公頃，在 20年間面積遽增30倍，主要原因在於此類水蜜桃，果肉爲溶質，果形大、糖度高、果形、色澤及風味均佳，民衆評價甚高，視爲高級水果。但是本省高海拔地區有限，在環境保護的觀念日益被重視，及自然景觀必須被維護的前提下，已不容許過度的開發高海拔山坡地，加以政府基於水庫淤沙及水庫安全使用年限問題，對高海拔地區果樹的栽培採取限制措施，並收回不合理利用之土地，今後的生產面積，將因此而無法再增加很多。

目前高海拔地區所栽培的水蜜桃，因其冬季休眠所需的低溫量（Chilling requirement）甚高，多在800～1,200小時之間，本省中海拔地區（600～1,200M）尙無法滿足其需要，更遑論低海拔地區了，因此要在平地栽培高品質的水蜜桃，利用引種及育種方法降低其後代之低溫需求爲可能的手段之一。

本文詳述近年來農業試驗所利用引種，實生選種及雜交育種等方法在改良低海拔桃品種之進展。

育種材料與方法

（一）育種材料：

1.引種材料：Albatros, Coral, Desertgold, Earligrande, Flordabelle, Flordagold, Flordared, Okinawa, Premier, Tutu 等。

2.育種材料：

A. 自然授粉（open-pollination）: Flordared, Premier, Tutu, Talisma 等。

B. 人爲授粉（controlled-pollination）：（a）高海拔品種：大久保，白鳳，松森早生，泉白桃，八幡白鳳，武井早生等，（b）低海拔品種：鶯歌桃、福州大桃，Flordaprince, Earligrande, Flordared, Premier, Okinawa 等。

（二）育種方法：

1.引種：從與本省緯度相近之地區引進高品質，冬季休眠所需低溫時數少之桃品種試種。

2.育種：

A. 自然授粉：將引進之品質優良、低需冷性之桃品種混植，讓其自然授粉再實生選拔。

B. 人爲授粉：（1）將本省在來品種與高海拔高需冷性之水蜜桃品種互相雜交。（2）將低需冷性水蜜桃品種與高海拔，高需冷性之水蜜桃品種互相雜交。（3）將低需冷性桃品種互相雜交。

（三）育種步驟：

1.引種及試種：由與本省緯度相近，冬季氣候暖和之地區如美國佛羅里達州，德克薩斯州；巴西、南美等地引入桃接穗，嫁接成活并在溫室隔離檢疫一年後，移出田間以5公尺×5公尺之行株距定植，並施以病蟲害防治，施肥，修剪等管理工作，試種之材料分別就落葉期、開花期、果實成熟期及果實特性等諸項目進行調查。調查項目基準如下：

落葉始期：全樹的25%的葉片脫落。

落葉終期：最後一批葉（個別葉片除外）脫落。

萌 芽 期：約有5%的葉芽頂端露出葉尖。

始 花 期：約有5%的花開花。

盛 花 期：約有25%的花開花。

末 花 期：約有75%的花落瓣。

開 花 期：從始花至末花的天數。

成 熟 期：大量果實達到9分熟。

果實發育日數：從末花期至成熟期之日數。

果實特性：調查果形、果大、果色、果重及風味。

2.育種：

A. 親本之選擇：選擇開花，萌芽期早，果實發育期短，果實品質佳之桃品種爲育種之親本。

B. 花粉收集及貯藏：高海拔桃開花期爲3月下旬～4月上旬，低海拔桃之開花期則從元月中旬～3月上旬，花期不同，在各開花期按雜交計畫所需採集花粉。採取預定於次晨開放之花蕾，用乾淨的鑷子取下花藥，舖放在培養皿中，置於定溫在25°C之開藥器內，讓花藥開裂，花粉散出後，收集在硫酸紙袋內，裝入含乾燥劑之玻璃瓶中，瓶外標明品種名稱及採粉日期，玻璃瓶分抽眞空及不抽眞空二處理，置於−20°C之低溫中貯藏。

C. 雜交授粉：低需冷性親本種植於農業試驗所萬豐試驗農場，高需冷性親本則由武陵農場提供。在元月份及2月份分別收集低需冷性親本之花粉，於−20°C，眞空之環境中貯藏至3月下旬，携至武陵農場，進行雜交授粉；同時採取高需冷性親本之花粉，同樣貯存在−20°C眞空之環境中至翌年元月及2月在農業試驗所萬豐農場進行雜交授粉。

D. 種子處理：果實成熟時，去除果肉後以鐵鎚敲擊外種皮使之裂開，取出種子，以億力（Benlate）消毒30分鐘後，再用潮濕的蛭石包埋，置於5°C中打破休眠。

E. 育苗：種子打破休眠後，待下胚軸伸出約1～2公分時，取出種植於以2份消毒土壤，2份蛭石，1份泥炭土所配成的培養土中培育，每星期定期施以花寶2號肥料（N：P. K＝20：20：20）一次。

F. 定植：實生苗於溫室培育到50公分左右，移到田間以75×200公分的密度栽培，生長期間

定時施肥及防治病蟲害。

G. 選拔：雜交及實生後代分別就落葉期、開花期、果實成熟期及果實特性如果肉溶質與不溶質、果形、果重、果皮及果肉顏色、糖度、離核或黏核等項目進行初級選拔。

3.胚培養：取各雜交組合之不同發育期之胚進行培養，培養前先將硬殼敲開，取出種子，以75%的酒精消毒15秒後，以無菌水清洗 3 分鐘，再以 10% Clorox+0.1% Tween-20 消毒15分鐘，最後再用無菌水清洗 3 分鐘。種子在無菌操作臺中取出，剝去種皮後置於 MS 基本培養基中培養，並比較添加 5ppm GA 對胚生長之影響。

結果與討論

(一) 種源之搜集與評估

雜交育種爲改良本省低海拔桃品質的主要途徑，希望經由雜交能將高冷地品種的優美果形、高糖度、果肉多汁等特性與低海拔品種冬季休眠不需太多低溫的性質結合，以使在平地也能够栽培高品質的水蜜桃。本省在來品種雖然冬季休眠所需低溫時數不多，但果肉爲不溶質，果形外觀亦差，如果能搜集到具有溶質果肉，果形美，在平地亦能開花結實的品種爲親本，可以縮短雜交次數，增進育種效率。

農試所自民國69年以來，即陸續自美國佛羅里達州、巴西、日本、南非、香港等地引進具有溶質果肉的水蜜桃等品種試種，截至76年底止共試種了 187品種，其中在本省中部平地可開花結實的計有鮮食桃22種、油桃 5 種、蟠桃 1 種、罐桃 1 種，花形、花色美麗而果實不堪食用的花桃 6 種，其花期、熟期、果實性狀詳載如表二。

表二、適合本省中部平地氣候之桃品種性狀表

Table 2. The characteristics of peach varieties suitable for lowland of central Taiwan

鮮食桃

品種名	盛花期	成熟期	果形	果重(g)	果肉顏色	糖度
Albatros	3月中旬	6月中旬	圓	70	白	10
Coral	3月下旬	6月中旬	圓	85	白	13
Cristal	元月下旬	7月上旬	圓	70	白	14.5
Desertgold	2月中旬	6月上旬	橢圓	95	紅	12.5
Earlibelle	3月上旬	6月中旬	橢圓	70	白	10.5
Earligrande	元月下旬	5月中旬	橢圓	100	黃	11
Flordabelle	元月下旬	6月上旬	圓	120	黃紅	12
Flordagem	3月上旬	6月下旬	橢圓	80	黃	9.5
Flordagold	2月中旬	6月上旬	橢圓	85	黃	12
Flordaking	2月下旬	5月下旬	橢圓	140	黃	11
Flordaprince	2月上旬	5月上旬	圓	80	黃	12
Flordared	元月下旬	5月中旬	圓	90	白紅	11
Maravilha	3月中旬	5月中旬	圓	65	白	9
Okinawa	元月上旬	5月下旬	橢圓	45	白	13
P-101	2月上旬	5月下旬	圓	180	白	9.5
Premier	2月上旬	5月中旬	圓	80	白	13.5
Sanpedro	2月上旬	5月下旬	橢圓	105	黃	9.6
Talisma	2月中旬	6月下旬	圓	90	白	15
Tutu	2月中旬	6月下旬	圓	85	白	14
16—33	2月中旬	5月下旬	橢圓	100	黃	11
甜桃	2月上旬	6月中旬	長圓形尾尖	55	白	14
鶯歌桃	3月中旬	6月中旬	長圓形尾尖	70	白	13.5

油　桃							
Columbina	2月中旬	5月下旬	圓	70	黃	9	
Sunred	2月下旬	6月上旬	圓	65	黃	9.5	
6—3	2月中旬	6月上旬	圓	75	黃	10	
7—4	2月下旬	6月上旬	圓	70	黃	10.5	
8—8N	2月中旬	5月下旬	圓	115	黃	10	
蟠　桃							
7—7	2月下旬	5月下旬	扁　圓	80	黃	11	
罐　桃							
Rio de Canserva	2月上旬	6月下旬	圓	125	黃	10	
花　桃							花　形
Swatow	2月下旬	—	—	—	—	—	紅色重瓣、矮性桃
中生白	3月中旬	—	—	—	—	—	白色、單、重瓣兼具
寒緋桃	3月中旬	—	—	—	—	—	艷紅色、單瓣
碧桃（I）	2月中旬	—	—	—	—	—	大輪花、白色重瓣
碧桃（II）	2月中旬	—	—	—	—	—	大輪花、紅色重瓣
碧桃（III）	2月中旬	—	—	—	—	—	大輪花、粉紅重瓣

引進之鮮食品種果肉皆爲溶質，糖度高，果皮著色美，品質遠非本省低海拔在來品種所能比擬，但仍有下列幾項待改進的地方：（1）本省緯度較引種地點仍低，大部分品種在本省中部平地仍有多季休眠時期低溫不足的問題，導致植株有花期延遲，葉芽萌芽不齊或不萌芽的現象。（2）大部分品種果肉爲黃色，且酸度高，與本省一般消費習性不同。（3）大部分品種的果形皆不大，平均果重多在120公克以下，不能與高冷地品種相比。

部分品種的特性甚佳，在短期的育種目標上是重要親本，玆詳述其特性如下：（因本省相關資料厥如，文中所敍述多季休眠低溫時數，皆爲原產國之資料）。

Earligrande：多季休眠所需低溫時數 200小時，平均果重 100公克，最大果重可達 250公克，果形橢圓，黃色果肉，離核，蕊開型花，果實 5 月中旬成熟，糖、酸比適當，爲目前所觀察品種中風味最佳者，其缺點爲果實不耐貯放。

Flordabelle：多季休眠所需低溫時數150小時，平均果重120公克，最大果重可達220公克，果形短圓形，黃色果肉、離核，果皮著色美，果實生育期長約需 110天，在本省中部 6 月上旬果實方能成熟。

Fordagold：多季休眠所需低溫時數 325小時，平均果重85公克，果形橢圓、黃色果肉、半離核，6 月上旬果實成熟，其缺點爲酸度稍高，果實成熟時，縫合線處易開裂，易罹灰霉病。

Flordaking：多季休眠所需低溫時數400小時，平均果重140公克，最大果重可達300公克，果實生育期短，從開花至成熟只需70天，果形橢圓形，黃色果肉，半離核，蕊開型花，果實 5 月下旬成熟，果肉纖維質多，缺點爲果實易罹灰霉病，結實率低。

Flordared：多季休眠所需低溫時數約75小時，平均果重90公克，果形圓形，白色果肉，離核，

5 月中旬果實成熟，樹勢强健，豐產，缺點爲果實酸度稍高。

Okinawa：冬季休眠所需低溫時數約 50小時，平均果重 45公克、果形圓形、白色果肉、離核，5 月下旬果實成熟，果實風味差。除作爲低需冷性之育種親本外，亦可作爲抗線蟲砧木。

Premier：冬季休眠所需低溫時數約 150小時，平均果重 80公克，果形稍橢圓形、白色果肉、離核，果肉細緻多汁，不帶酸味，爲適合國人口味之品種，缺點爲果形太小。

P-101：平均果重180公克，最大果重 450公克，爲平地水蜜桃品種中最碩大者，果實圓形，白色果肉，離核，5 月下旬果實成熟，雄蕊不稔，須種植授粉樹，以使結果安定。其缺點爲果實酸度太高。

（二）實生選種

根據日本已發表之桃品種其來源有60%以上是所謂的偶發實生苗[4]，此說明實生選拔是桃育種的一個有效途徑。73年度由混植之低需冷性水蜜桃品種，經由自然授粉（open-pollination），培育了814株實生苗，以75×200公分的密度定植農試所選拔園中，經過75年度之初選，76年度複選，由此後代中選出 1—20、2—53、4—67、5—48、6—6、6—10、7—32、20—58 等 8 個果重超過 100公克，果實風味佳之品系，其開花期、成熟期、果重、糖度、果肉顏色等特性詳載表三。

選拔園採取高密度栽培可以節省選拔園所需之空間，但因密植的關係也衍生了如下的問題：1.生長勢較弱的植株，易因養水份競爭處於劣勢而遭淘汰。2.密植的結果導致通風不良，樹勢徒長，及病蟲害容易滋生。3.因密植的關係導致根系間相互競爭，養、水份的吸收不如正常栽培園，因此，果形、果重及風味無法充分發揮。因此，選拔園管理上特別注意修剪及病蟲害防治，並快速淘汰不良後代。合於初選條件之優良後代，經嫁接繁殖，以便進行區域試作，進一步觀察其他特性。實生選拔試驗繼續在進行，至76年度，累積觀察之實生苗已超過2,000株。

表三、由開放授粉選出之優良品系其開花期、成熟期及果實特性調查表

Table 3. The characteristics of 8 peach selections from open pollination that show promise for advanced tests

編　號	母　本	開花期	成熟期	果重 (g)	果　形	糖度 (%)	果肉顏色	核　性
1—20	Flordagold	元月下旬	5月中旬	155	圓	10	紅	離　核
2—53	Tutu	元月中旬	6月下旬	115	圓	11	白	離　核
4—67	Flordared	元月下旬	5月上旬	100	圓	9.5	白中帶紅	離　核
5—48	Premier	元月下旬	5月下旬	115	橢　圓	12.5	白中帶紅	離　核
6—6	Talisma	2月上旬	6月上旬	140	圓	11.2	白中帶紅	黏　核
6—10	Talisma	2月上旬	6月上旬	120	圓	11	白中帶紅	黏　核
7—32	Talisma	2月上旬	6月中旬	145	圓	13	白	黏　核
20—58	Cristal	2月中旬	6月下旬	70	扁　圓	10.6	白	離　核

（三）雜交育種

雜交育種以下列 3 種途徑進行：（1）本省在來品種與高海拔水蜜桃品種互相雜交。（2）低需冷性桃品種與高海拔之高需冷性水蜜桃品種互相雜交。（3）低需冷性桃品種互相雜交。(1)(2)項爲高、低海拔不同需冷性桃品種雜交。因海拔高度及品種的差異，兩者之花期不同。低海拔桃品種（包括在來之鶯歌桃及引進之低需冷性桃品種）之花期爲元月～2 月間，高海拔栽培之高需冷性水蜜桃品種之花期則在 3 月下旬～4 月上旬。以低海拔之低需冷性品種爲父本，高海拔之高需冷性品種爲母本時，花粉需經 1～3 個月之貯藏，而以高海拔高需冷性品種爲父本，低海拔低需冷性品種爲母本時，花

粉需經 9 ～11個月之貯藏。花粉經長期貯藏後之萌芽率，直接影響雜交授粉的成績。保持花粉的活性，有助於育種效率的提昇。

在桃之雜交育種上常有雜交胚退化之情形(6,7,8,10) 本試驗亦進行不同雜交組合胚退化率及早期胚培養之研究，以提高育種效率。

1.花粉長期貯藏方法之研究

花粉採集後，進行低溫（－20°C）乾燥貯藏，花粉瓶分抽眞空及不抽眞空二組，比較其效果，於貯藏10個月後，調查花粉萌芽率。發芽培養基以 1 % agar 及20%蔗糖組成，將上述成份煮溶後，放置於室溫約 2 分鐘，稍冷却後再倒於載玻片上成一厚約 1mm 之薄膜，做爲發芽床，將桃花粉輕播於發芽床上，再將其置於培養皿內，加蓋，蓋內並附加二層濾紙，加水使其潤濕。將上述發芽皿置於 25°C 之培養箱中，經 8 小時後取出鏡檢，以花粉管長度超過花粉粒 2 倍者爲準，計算發芽率，重覆四次，結果如表五所示。

表四、抽眞空對長期低溫（－20°C）貯藏花粉後萌芽率之影響

Table 4. Effect of vacuum on pollen germinations of peach after long term, low temperature storage.

品種 ＼ 處理	抽眞空 *	對照組 **
白鳳	70%	30%
大久保	55%	15%
山根白桃	90%	—
八幡白鳳	70%	—
秀峰	50%	—

*76年 3 月25日貯藏，77年元月25日鏡檢。
**73年 3 月19日貯藏，74年元月19日鏡檢。

白鳳及大久保之花粉貯藏在眞空中10個月後較對照組之萌芽率提高40%，花粉長期貯藏後之萌芽率依品種不同而有差異，最高爲山根白桃90%，其次爲白鳳及八幡白鳳70%，大久保55%，秀峰最低50%。

2.不同海拔桃品種雜交胚退化情形：

七十三年元月及二月分別在平地收集 Okinawa 及 Flordagold 等品種之花粉，於低溫乾燥之環境中貯藏至三月中旬後，攜至武陵農場，分別與西野白桃、松森早生、白桃、白鳳、中津白桃、秋白桃、大久保、砂子早生等高需冷性品種進行雜交。在所採收的 113個成熟果實中，不成熟胚及只留種皮的退化胚共70個，其中西野白桃果實成熟後，內果皮已裂開，種子發霉腐爛，無法獲得雜交後代，松森早生、砂子早生在果實硬熟時種子尚未發育完全（PF≒40～60），仍有液狀胚乳存在，無法以一般濕冷層積法讓其發育成苗，其餘與白桃、白鳳、中津白桃、秋白桃及大久保雜交之組合，雖能得到成熟種子，但仍有相當高比例的未成熟胚及退化胚。七十三年三月於武陵農場收集白鳳、大久保及松森早生之花粉貯藏至七十四年元月～二月再於農試所果園與 Flordared、Premier、Okinawa、Flordagold、Talisma、Tutu、Cristal 等平地低需冷性桃品種雜交，在所採收的146個成熟果實中，只有10個未成熟胚及退化胚。在平地低需冷性桃品種間互相雜交組合之果實中，則無未成熟胚、也無胚退化現象（表五）。

表五、不同海拔桃雜交組合之未成熟胚及退化胚百分率

Table 5. The percentage of immature and abortive embroys in different combination of peach hybridization

雜交組合	收穫果數	未成熟胚及退化胚數	未成熟胚及退化百分率 (%)
高需冷性親本×低需冷性親本 **	113	70	≒ 62
低需冷性親本×高需冷性親本 ***	146	10	≒ 6.8
低需冷性親本×低需冷性親本 ***	67	0	0

**73年於武陵農場進行
***74年於農業試驗所進行

以高需冷性品種爲母本時，未成熟胚及退化胚的比率高達62%，但是以低需冷性品種爲母本時，則只有6.8%，低需冷性品種間互相雜交，則胚沒有不成熟及退化之情形。此一現象，除了內在基因作用外，果實發育過程中外界環境溫度的影響，也是重要原因之一。本省高海拔氣候多變，開花後常有突發的低溫及晚霜，嚴重影響胚的發育，平均溫度低及日夜溫差大亦會延緩胚發育到成熟的時間，這些現象在平均溫度較高而溫差較小的平地，情況大爲改善。

以高海拔高需冷性品種爲母本時須行早期胚培養以提高雜交苗之獲得，尤其以早生品種爲母本時爲然。

3.胚培養於本計畫之應用：

(A)低需冷性親本×高需冷性親本

因雜交果實常遭竊取，不得不於成熟期之前採收進行胚培養，以保護試驗結果。73年度試驗成果顯示，自授粉第50天起（$PF_1=33$）即可將胚置於 MS 培養基中於 25°C 培養之。經兩個月即可長成小植株，PF_1 越高，長成小植株所需的時間越短，幼苗也愈健康，授粉後80天之胚（$PF_1=100$），培養於 MS 培養基，接種後之胚置於 5°C，兩星期後胚根即可長出，待胚根長出後移至 25°C，上胚軸迅速長出，有部份雜交苗表現簇生葉現象。接種後之胚置於 25°C 中，胚亦無休眠現象，只須兩星期即可長成小植株。早期胚培養除可保護試驗成果外，亦可省去層積打破休眠的時間。造成簇生葉的原因可能是由低溫不足引起，剪去頂芽讓側芽萌生即可正常生長。

(B)高需冷性親本×低需冷性親本

73年度所作高、低海拔雜交親合率測定顯示以高海拔品種爲母本時有三種可能而致無法得到雜交後代：

(1) 早生品種如松森早生、砂子早生等果實成熟時其胚尙未完全成熟，以濕冷層積法無法使其發芽。

(2) 晚生品種如秋白桃、種子在果實成熟時已退化萎縮，無法獲得雜交種子。

(3) 西野白桃之果實成熟時，內果皮裂開（裂核），而且種子霉爛或退化，無法取得雜交種子。

高海拔水蜜桃之胚生長較平地品種慢，取砂子早生授粉後90天之胚（$PF_1≒33$）培養於 MS 培養基上，經過六星期後，只有少部份胚可長成植株，但甚爲幼弱，移出管外容易死亡。但是如在硬熟期將胚（$PF_1>80$）取出培養，則可以在試管中讓其繼續發育，改善早生品種胚未完熟而無法獲得雜交後代的困難。75年 7 月將以松森早生爲母本的雜交胚置於 MS 及 MS+5ppm GA_3 的固態培養基中培養，於 5°C 中層積四個月

後，再移至日溫 25°C、夜溫 21°C 的環境中培養，兩星期後測量其根、莖之長度，胚在添加 GA_3 的培養基中根的生長受到抑制，莖的生長量也不到對照組（MS）的一半（表六）。

表六、不同培養基培養以「松森早生」爲母本之雜交胚18週後之莖、根生長量*

Table 6. Average length of shoot and root growth of hybrid embryo in different media after 18 weeks of culture.

處　理	莖平均生長量(cm)	根平均生長量(cm)
MS	3.52	3.78
MS+5ppm GA_3	1.45	0.63

*前16週於 5°C，後2週於日溫 25°C、夜溫 21°C

植株移出管外前先於 25°C 環境中逐步打開瓶蓋，讓其健化，再移至溫室定植於已消毒之土壤中，初期以玻璃燒杯覆蓋以保持濕度，防止萎凋。

本試驗旨在探討胚培養之最適胚期，MS 雖然爲目前常用之培養基，但不一定適合桃胚之生長與發育，由文獻看來較令人滿意的培養基有 Hoagland solution [5] 和 Knop+Heller 的微量元素 [9]，Tukey 的配方則有助於發根 [7]，今後的研究方向爲比較各種不同配方之培養基以提高胚培養成功率，使此一技術在桃育種上實用化。

4. 初選之優良品系：

至76年度爲止，共培育了1,500株左右的雜交苗，同樣地以70×200公分的密度定植田間進行選拔。就已開花結實之後代中選出 5—9，12—8，22—35等3個果大、風味佳、適應本省低海拔氣候之品系，值得進一步觀察，其萌芽期、成熟期及果實特性詳載表七。

表七、由雜交後代中選出之優良品系其萌芽期、成熟期及果實特性表

Table 7. The characteristics of 3 peach selections from hybridization that show promise for advanced tests

編號	親本	開花期	成熟期	果重(g)	果形	糖度(%)	果肉顏色	核性
5—9	Tutu×Flordagold	元月上旬	5月下旬	130	橢圓	11.5	白	離核
12—8	Talisma×Flordared	二月中旬	5月上旬	135	圓	11	白	離核
22—35	白鳳×Okinawa	元月下旬	6月中旬	120	圓	12	白	離核

結　論

Mitcrin 從事果樹育種幾十年的心得認爲在果樹的實生苗階段，它們的適應性有最大的程度之發展，也就是可塑性最大，到了結果2～3年後就幾乎完全消失 [3]。果樹引種要由氣候條件類似的地區引進才有成功的機會，因爲果樹一般以嫁接繁殖保持其本來之優良性狀，但此時枝條的可塑性極爲有限，氣候環境相異之地區，難望有成。實生選拔有助於果樹對不同氣候之適應，但其程度亦有限。高、低海拔桃品種的雜交後代，可在平地開花結果，這說明雜交是最有效的改良方法，尤其是利用地理上和生態上遠緣的植物做親本，可以增加它們的雜種後代對新環境之適應力。

本省高海拔地區可耕地有限，加以生產成本高，運輸不便等等不利的條件，果樹的栽培必須走向

平地，以自動化、機械化來提高生產力，降低成本。本省桃之平地化育種工作中水蜜桃只是一個開始，其他如油桃、蟠桃、罐桃、矮性桃的育種，亦已仿此模式陸續進行中，相信不久的將來，高品質的各式桃果可在寶島的各地開花結果。

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Improvement of Taiwan Lowland Peach[1]

Ien-Chie, Wen, H. T. Hsu*, S. C. Lin**[2], M. S. Ro[3] and M. N. Chiang[4]

Summary

To improve lowland peach of Taiwan, several cultivars, including peach, nectarine, peen-tao and canning peach, were selected as parents for hybridization.

The frequency of embryo abortion in some combination low×high chilling requirement varieties was high, while immature embryos 50 days post pollination; from high ×low chilling requirement varieties in firm ripen stage could be rescued by *in vitro* culture, which also increased germmination rate.

Peach pollen, which stored under vacuum and −20°C condition, has 40% higher grmination rate than those only under −20°C condition.

A high density fruiting unrsery for evaluation of peach seedlings has been adopted to shorten the time from planting to first fruiting and to save selection space.

Eleven selections showed promise for advanced test.

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2. Assistant fellow, associate research fellow and research fellow, Dep. of Horticulture, T. A. R. I., Taichung, Taiwan, R. O. C.

3. Professor, National Chia-Yi Institute of Agriculture.

4. Professor, Department of Horticulture, National Taiwan Univ.

*. Associate research fellow and Head, Dept. of Horticulture, Chia-Yi Agriculture Experiment Station, T. A. R. I., Chia-Yi, Taiwan, R. O. C.

**. Director, Tainan District Agricultural Improvement Station, Tainan, Taiwan, R. O. C.

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田菁中間作與耕耘方式對水稻、玉米輪作田土壤理化性質及玉米生產之影響[1]

連　深　王鐘和[2]

摘要　在霧峰（本所）一處探討第一期作水稻後之田菁中間作及其處理方式（整地掩埋及不整地敷蓋）對秋作玉米生育，收量及氮需要量之效果。

一期稻作收穫數天前撒播之田菁生育迅速，到秋作玉米播種時乾物生產每公頃可達5公噸左右，含氮、磷酐、氧化鉀各約120、25、及90公斤。

此項田菁可以應用本所農場之『圓盤切割式玉米不整地施肥播種機』壓倒，同時施肥播種。壓倒後之田菁則成爲玉米田之敷蓋物，對玉米之生育，收量及氮肥的節省均有顯著效果。不整地下表土之粗孔隙率很低；pF1.5之氣相率只及5.2%，而有田菁中間作者則增爲13.8%，顯著改善其通氣性。其pF1.5～pF3.0之水分率（即易有效水分率）亦略有增加，達15.4%。田菁中間作敷蓋區較對照區每公頃平均增產玉米約400公斤，另可節省氮素約50公斤。

整地區之玉米生育較不整地區者略差，收量及氮肥之效應亦是較低。在施用磷酐60kg/ha下，整地區之玉米初期生育仍呈缺磷；其表土之粗孔隙率大（pF1.5之氣相率達28.5%），而易有效水分則低（pF1.5～pF3.0之水分率僅及12.2%）。中間作田菁以傳統方式掩埋對玉米生育、收量之效果，亦較不整地區以中間作田菁作敷蓋者差。

關鍵字：稻田轉作，玉米，田菁中間作，耕耘方式。

本省中南部稻田推行玉米轉作，以第二期稻作轉秋作玉米爲宜，蓋第二期稻作收量顯著低於第一期作而玉米收量則以秋作顯著高於春作故。若將兩期稻作全部轉作玉米則恐消耗地力太大而且對於病蟲害之防治亦屬不利。

惟當第二期稻作決定轉作秋玉米時自第一期作水稻收穫至玉米播種約有兩個月（即七、八月）期間，時值颱風季節，高溫多濕，除小部分稻田可栽培香瓜、蔬菜外，大部分並無適當作物可以栽培。夏作大豆雖爲試作探討之一個目標，但在颱風季節下其收益性能否穩定仍屬疑問。

田菁雖非現金作物，却很適合於該期間栽培，並預料可以防止雜草之叢生及對其後作有良好效果。據報告(7)本省中南部各種模式之轉作年純收益依次爲：1）春作高粱—宿根高粱—秋裡作玉米，2）一期水稻—夏作田菁（即田菁中間作）—秋作玉米，3）一期早稻—夏作瓜類—秋作玉米，4）一期早稻—夏作大豆—秋裡作玉米，5）一期水稻—二期水稻（對照）。亦有報告(3)以2）一期水稻—夏作田菁—秋作玉米之收益性爲最高者。可見一期水稻—夏作田菁—秋作玉米爲相當合適的轉作模式。

惟傳統的耕作方法，夏作田菁係於秋作玉米播種前耕耘掩埋，土壤却因該時期常遇驟雨吸收大量

1.臺灣省農業試驗所　研究報告第 1435 號

2.臺灣省農業試驗所農化系研究員及助理。臺灣省　臺中縣　霧峰鄉。

水分而延誤玉米播種時期。反之，播種後之玉米，一旦天氣放晴則常因土壤乾旱而缺磷。爲免以上缺點，不整地栽培乃爲最佳方法，惟此時田菁之處置亦成問題。田菁究應整地後掩埋？抑或不整地當玉米田之敷蓋？此等處理對秋作玉米之生育，收量及氮肥需要量有何影響？此等作物制度長期對地力之影響如何？等均值得探討。

作物複作制度之研究事關太陽能、水及土地資源之有效利用[9]，其重要性不待多述，必需就各個環境分別探討。據 Phetchawee et al.[5] 報告，玉米田若干綠肥作物間作（intercropping）或間作一段期間後砍斷作爲敷蓋對玉米之生育，收量均有良好的效果，惟預料此種間作係在玉米收量水準不高情形下才可行。

本研究目的主要在於探討田菁中間作及處理方法(整地掩埋與不整地敷蓋)對秋作玉米生育、收量及氮需要量之效果，並應用圓盤切割式施肥播種機探討田菁中間作田玉米不整地省工栽培之可行性。

材料與方法

1.中間作

自一期水稻收穫至秋作玉米播種期間設下列兩種處理：

（1）栽培田菁（即施行田菁中間作）

（2）休閑（即不施行田菁中間作）

田菁於水稻收穫前 3～5 日播種（30 kg/ha）。水稻收割係使用聯合收割機，並將收割後之稻藁細切後，撒施於田間。故不論田菁區或休閑區地面均有基本上之稻藁敷蓋。各區面積 136平方公尺（13.6m×10.0m）。隨機區集排列，5 區集。

2.秋作玉米

（1）試驗設計：爲雙裂區設計，以整地與不整地爲主處理，田菁中間作之有無（詳細如材料與方法1.所述）爲副處理，3 種氮肥平準爲副副處理。小區（即副副處理區）面積爲42m^2（4.2×10m），6 行區，行株距70×25cm。區集數，整地及不整地主處理各爲 2 及 3 。

（2）處理內容：

（A）整地與不整地及中間作田菁之處理方法：

整地區係以圓盤犁（1987年以後使用迴轉犁）翻犁，耙平後以「圓盤切割式施肥播種機」施肥播種。播種溝與施肥溝間距爲 3～5cm，施肥溝深約爲 2～3cm。區內遇有中間作田菁（副處理），則於行走圓盤犁（或迴轉犁）時掩埋土中。第一期作之稻藁亦是基本上被掩埋土中。

不整地區係使用「圓盤切割式施肥播種機」直接施肥播種，而不翻犁土壤。區內遇有中間作田菁（副處理），則於行走該施肥播種機時被壓倒地面，隨即噴施巴拉刈，田菁枯死後即成爲玉米田的地面敷蓋。第一期作之稻藁亦是基本上敷蓋於地面。

（B）肥料處理：

副副處理所設 3 種氮素用量爲：(1)60、(2)120及（3）180 kg/ha（1986年用量爲(1)(2)(3)各70、130及190kg/ha）。

(1)(2)(3)處理均於玉米播種時施用臺肥39號複合肥料500kg/ha，合N、P_2O_5、K_2O各60、90、60kg/ha（1986年施用583kg/ha，合N、P_2O_5、K_2O各70、105、70 kg/ha）。(2)(3)處理再於玉米膝高期追施尿素130kg/ha（合N 60kg/ha），而(3)處理則再於抽穗期追施尿素 130kg/ha（但1985及1986年之追、穗肥均使用硫酸銨）。整地區於施用膝高期追肥時，以人工培土，作畦。反之，不整地區則於膝高期追肥時並不培土作畦。至於抽穗期追肥則整地區係施於畦底，而不整地區則與膝高期相同，均係撒施於行間（但施肥前灌水，使地面潮濕後才施肥）。

3.實施地點：

本所66號田。土壤母質爲粘板岩、砂頁岩混合新沖積，表土質地爲SiL，pH4.7，有機質含量1.6%。

4.調查與分析項目：

（1）田菁收量及三要素含量。

（2）玉米生育初期之表土理化性質，包括有效磷含量及土壤的總體密度、總孔隙率、pF1.5 之氣相率（即粗孔隙率）及 pF1.5～3.0 之水分率（即易有效水分率）。總體密度係以土柱（soil core）法測定，pF1.5 之氣相率及 pF1.5～3.0 之水分率則係將田間所採土柱裝置於 Tempe-Pressure Cell（Soil Moisture Co. 製品）加壓測定。

（3）玉米之生育狀態（包括植株之乾物量及要素含量）及子實收量。

結果與討論

1.中間作田菁之收量及要素含量

一期稻作收穫3～5天前（7月初旬）所撒播之田菁，因時值高溫多濕，生長迅速，至9月初旬秋作玉米播種時鮮草收量達 24～31t/ha，乾物量則達 4.7～5.8t/ha，三年之平均爲 5.1t/ha（表1）。如此收量較之推廣手册[2]或張學琨（1963）等[4]所報夏季糊仔田菁均顯著的高（鮮草收量 10～20t/ha），其主要原因可能與生育日數之差異有關。本試驗之田菁收穫時均已接近或達開花期，惟其 N、P、K 含有率則依年度而稍有變異；各爲1.7～2.5、0.17～0.23及1.0～1.6%，平均各爲2.1、0.20及1.30%，而 N、P_2O_5 及 K_2O 含量則各爲107、23及 80kg/ha。此等要素含量之數據亦較推廣手册[2]所報顯著的高；該手册所報導田菁三要素含有率爲 N、P、K 各0.47、0.05及0.35%，顯然太低，應加修正。

表1. 水稻玉米輪作田田菁中間作之收量及要素含量

Table 1. Yield and element content of Sesbania grown as interseason crop in the rice-corn system (Wu-feng, 1985～1987)

調查項目 Items studied ＼ 年度 year	1985	1986	1987	平均 mean
Yield (t/ha)				
Fresh	31	24	—	24～31
Dry matter	5.8	4.7	4.7	5.1
Element concn. (%)				
N	2.5	2.1	1.7	2.1
P	0.23	0.17	0.19	0.20
K	1.60	1.34	0.96	1.30
Ca	0.86	—	—	—
Mg	0.088	—	—	—
Element content (kg/ha)				
N	142	100	80	107
P_2O_5	31	19	20	23
K_2O	110	75	54	80
CaO	70	—	—	—
MgO	8.9	—	—	—

2.田菁中間作及整地與否對秋作玉米生育、收量之效果：

如材料與方法所述，本試驗秋作玉米之田間處理包括整地與否（主區），田菁中間作之有否（副區）（中間作田菁在不整地區是當玉米田之敷蓋，而在整地區則掩埋），及氮素用量之不同平準（副副區），係連續在同一田區進行試驗。其1985～1987年各處理區秋作玉米之收量如表2。三年間之收量平均如圖1。

表2. 水稻玉米輪作田田菁中間作之有否及玉米田之整地與否對玉米收量之效果（臺農351號，霧峰本所，秋作）

Table 2. Effect of interseason cropping of Sesbania and tillage on the yield of corn under rice-corn system (TNG 351, Wu-feng, 1985～1987)

處理區別 Treatments		1985	1986	1987	平均 mean
T_0G_0	N_1	2.85	3.67	3.36	3.29
	N_2	3.95	4.86	3.87	4.23
	N_3	4.14	5.12	3.95	4.40
T_nG	N_1	4.22	4.76	4.10	4.36
	N_2	4.45	5.24	4.51	4.73
	N_3	4.83	5.27	4.62	4.91
LSD (5%) 同氮素平準下 G_0 與 G 之差		0.77	0.54	N. S.	0.34
TG_0	N_1	3.50	4.40	4.11	4.00
	N_2	4.01	4.66	4.27	4.31
	N_3	4.08	4.81	4.22	4.37
TG	N_1	4.30	4.49	4.24	4.34
	N_2	4.51	4.55	4.28	4.47
	N_3	4.47	5.00	4.15	4.54
LSD (5%) 同氮素平準下 G_0 與 G 之差		0.62	N. S.	N. S.	N. S.

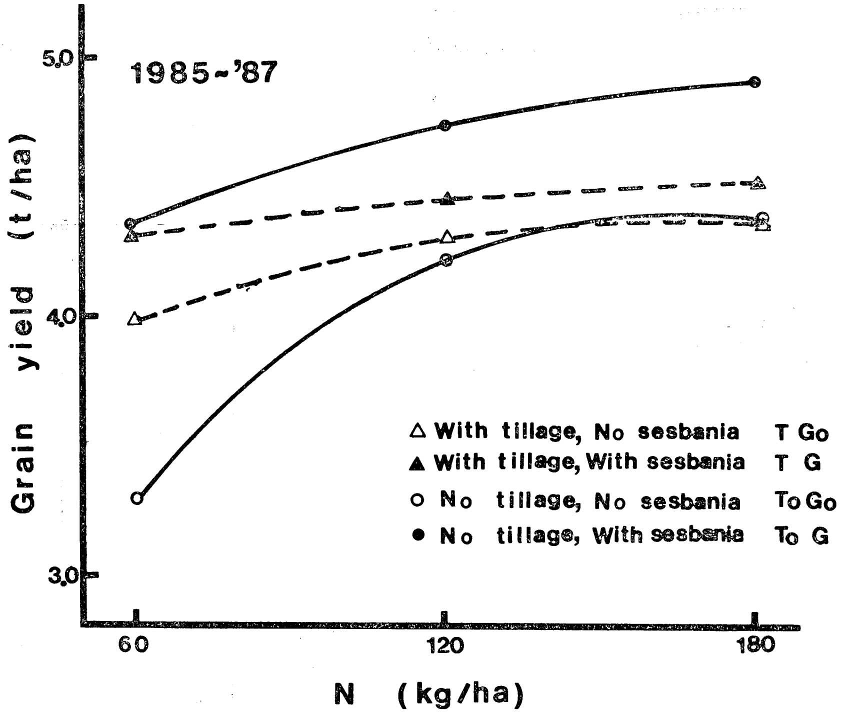
註：T 及 T_0 各代表玉米田之整地與否，G 及 G_0 各代表玉米田有否田菁前作（即水稻—玉米之中間作），$N_1N_2N_3$各代表玉米田之氮素用量平準（各60、120及 180kg/ha，但1986年例外為各70、130及190kg/ha）。

本試驗玉米田之試驗設計雖為雙裂區，但因整地與不整地各主處理之區集數不同，故收量之變方分析及平均值差異之顯著性測定係依各主處理別進行。

（1）不整地下之中間作田菁敷蓋效果

如材料與方法中所述本試驗中不整地區之玉米施肥播種係應用本所農場研製之「圓盤切割式不整地施肥播種機」進行；其中遇有田菁中間作，副區則使用該機壓倒的同時施肥播種，隨即撒施殺草劑（巴拉刈）而壓倒後之田菁則成為玉米田之敷蓋物。

雖然田菁中間作區（T_0G）及對照區（T_0G_0）均有前作稻敷蓋（5 t/ha左右），但田菁中間作區因尚有田菁敷蓋，其敷蓋情形較對照（副）區顯著良好，雜草較少。其玉米生育自始即較對照區良好，子實收量亦顯著增高（表1及圖1）；在 $N_1N_2N_3$ 各級氮素用量平準之下，田菁中間作敷蓋區較



圖一、水稻玉米輪作田田菁中間作之有否及玉米田之整地與否對玉米收量之效果（臺農 351 號，霧峰本所1985～1987秋作平均）

Fig. 1. Effect of interseason cropping of Sesbania and tillage on the yield of corn under rice-corn system (TNG 351, Wu-feng, mean of 1985～1987)

對照區各增產1.07、0.5及 0.5t/ha（1985、1986及 1987 三年平均），顯示田菁中間作敷蓋的效果在少氮下最爲明顯；即使在充足的氮素用量下，田菁中間作敷蓋區之收量仍高於對照，顯示前者有氮素的供給以外的效果。田菁中間作敷蓋區之玉米氮素需要量以 140kg/ha 爲已足，而對照區之氮素需要量則達 170kg/ha 左右，顯示前者約可節省氮素 30kg/ha 左右。

（2）整地下之中間作田菁掩埋效果

在玉米整地栽培區，其前作之田菁（即水稻—玉米輪作田之田菁中間作）係按一般習慣，於耕犂時將其掩埋於土中，然後施肥播種。在本試驗中此項處理區（TG）亦較其對照區（TG_0）有子實收量上的顯著增產，但其增產量已較不整地下之田菁中間作敷蓋區爲低；在 $N_1N_2N_3$ 各級氮素用量平準下，田菁中間作、掩埋區較對照區各僅增產0.3、0.2及 0.2t/ha（1985、1986及1987三年平均）。氮素需要量之節省亦較不整地下之田菁中間作、敷蓋區爲小。

（3）整地與不整地效果之比較

由圖 1 整地區與不整地區收量之氮素效應可見，在少氮用量下，整地區之玉米收量有顯著高於不整地區之趨勢，但在多氮下，却反之。此種傾向與前人所報[(6) (8)] 相當符合；即因整地可以促進土壤氮素的礦化，故在少氮下可以減少一些缺氮的壓力。反之，在充足氮肥施用下，則整地區上述氮素礦化之利處已不存在，而其土壤物理性面之短處（如整地區表土較不整地區鬆，易缺水，灌漑後却易變密實，如下節所論）却會顯現，故其收量當較不整地爲低。

在整地下中間作田菁之掩埋原可期待其有較多之氮素礦化，因此可以期待其可節省較多氮肥，但由圖 1 所示同是整地下之田菁中間作掩埋區和其對照區之氮素效應（或氮素需要量）相當接近，可見

該項期待並不正確。此外中間作田菁掩埋不但較不整地敷蓋耗工，遇雨時耽擱播種期（因土壤被水飽和）之困擾亦是較大。

3.田菁中間作及整地與否對表土粗孔隙率及易有效水分率之影響

表3. 田菁中間作及整地與否對表土粗孔隙和易有效水分率之影響（1986秋作）

Table 3. Effect of interseason cropping of Sesbania and tillage on some physical properties of soil (Wu-feng 1986)

處理區別 Treatments	粗孔隙(%) Porosity (%) at pF 1.5	易有效水分(%) Moisture (vol. %) between pF 1.5 & pF 3.0	總體密度 Bulk density	總孔隙率 (%) Total porpsity
T_0G No-till Sesbania mulched	13.8	15.4	1.21	54.3
T_0G_0 No-till no Sesbania	5.2	14.5	1.36	48.7
TG_0 Tilled no Sesbania	28.5	12.2	1.02	61.5
The criteria in Japan (1)	>10	>15		

表4. 田菁中間作及整地與否對土壤和玉米植體氮、磷含量之影響（TNG 351, 1986秋作）

Table 4. Contents of nitrogen and phosphorus in the corn plants and soils with and without sesbania interseason cropping and tillage (TNG 351, fall crop, 1986).

處理區別	不整地 No-till		整地 Tilled	
Treatments	Control	Sesbania mulched	Control	Sesbania incorporated
Plants, 22 days after planting[2]				
N (%)	4.04	4.49	4.42	4.46
P (%)	0.306	0.364	0.283	0.269
K (%)	3.83	4.37	3.75	3.75
P deficiency	—	—	+	+
Soils[1], 22 days after planting[2]				
Bray P (ppm)	9.41	9.04	9.99	ND[4]
NH_4-N (ppm)	5.2	4.8	5.3	ND
NO_3-N (ppm)	15.2	16.7	10.8	ND
Moisture (%)	25.2	27.3	19.2	ND
Ripening stage[3]				
Bray P (ppm)	5.3	4.0	5.9	ND
NH_4-N (ppm)	8.9	8.8	9.2	ND
NO_3-N (ppm)	14.0	24.9	21.7	ND

1) 0～15cm plow sole. 2) Oct. 1. 3) Middle of Dec. 4) No determination.

表3爲第一期作水稻收刈後，經過七月初旬～九月初旬期間，田菁中間作或休閑後以整地和不整地兩種方式播植秋作玉米後之表土粗孔隙率和易有效水分率情形。可見不整地區中無田菁中間作者（T_oG_o），土壤相當密實，總體密度爲1.36，而粗孔隙率則僅及5.2%。不整地區中有田菁中間作（T_oG），則土壤之粗孔隙顯著增加（13.8%），達到日本『地力增進基本指針』中所規範之標準[1]。其易有效水分率亦較無田菁中間作者（T_oG_o）略有增加而達標準。

整地區（TG_o）土壤之粗孔隙率雖較不整地區顯著增加，却導致易有效水分率之降低（亦即粗孔隙增加，毛細孔隙却降），對於水分之保持或養分（尤其是磷）在土壤中之擴散不利。事實上，因秋作玉米初期天旱時，整地栽培之玉米較不整地者植體中之磷含量顯著的低（表4）而有缺磷徵狀，雖然兩者均施有 P_2O_5 60kg/ha 之基肥。整地區與不整地區土壤之有效磷測值並無差異之情形下發生上述玉米磷營養上之差異，顯然與土壤中的易有效水分低，磷的吸收較難有關。

結論與建議

傳統之「水稻—田菁—玉米」輪作制度中之玉米係在田菁掩埋後播植，比較耗工。遇雨時，且有延擱播種期（因土壤被水飽和）之困擾。

應用「圓盤切割式不整地施肥播種機」將田菁壓到的同時施肥播種，則既省工，且不受雨季的影響，可較順利播種，而田菁敷蓋物則對玉米之生育，收量以及氮肥之節省均有顯著效果。應擴大示範觀察其實用性。

誌　　謝

本試驗所應用之「圓盤切割式不整地施肥播種機」係承本所農場賴主任吉雄提供，謹誌謝忱。

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Effect of Interseason Cropping of Sesbania and Tillage on Corn Production under Rice-Corn System[1]

S. Lian and C. H. Wang[2]

Summary

In the cropping system converting the second crop rice for corn, the paddy fields after the harvest of the 1st crop rice are either fallowed or planted with interseason crop during the summer season. (Corn is not suitable for cultivation during summer due to the rainy weather and typhoon harzards.) Sesbania roxburghii is a suitable green manure to be grown as an interseason crop. The Sesbania plants grow profusely and the dry matter yield of the shoot during the period from early July to early September amounts to 5.1 t/ha, which contain 107, 23 and 80 kg/ha of N, P_2O_5 and K_2O respectively.

The Sesbania plants were pushed down by a mechanized disk cutting type seeder. fertilizer applicator, which planted corn seeds and banded basal fertilizers aside the seeds simultaneously without tilling the soil. The control plot was planted and banded with fertilizers similarly except that no Sesbania plants had been grown on the plot previously. Herbicide was applied soon after the planting to kill the Sesbania plant and to control weeds. Another control plot was conducted similarly except that corn was planted under tilled condition and the Sesbania plants had been incorporated into soil before the planting.

The growth of corn plants was much better in the plot with Sesbania mulching under no-till condition than in the control plots. The soil physical properties related to aeration and moisture retension was better, and nitrate content was slightly higher too in the former than in the latters. Consequently, the yield of the plot with Sesbania cropping & mulching was significantly higher than those of the control plots, besides the requirement for N fertilizer was much smaller due to the supply of nitrogen from the Sesbania residues.

The interseason cropping of Sesbania and its disposition as mulching for corn under no-tillage is highly recommendable in the rice-corn system.

key words: paddy field diversion, corn production, no tillage, sesbania interseason cropping, mulching.

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1. Contribution No. 1435 from Taiwan Agricultural Research Institute.

2. Soil scientist, and assistant respectively, Department of Agricultural Chemistry, TARI, Wu-feng, Taiching, Taiwan, R. O. C.

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Root rot of macadamia caused by *Ganoderma lucidum* and *Kretzschmaria clavus in Taiwan*

Pao-jen Ann[1] and Wen-hsiung Ko[2]

Abstract : About 10% of macadamia trees at Puli showed various degrees of decline due to extensive root decay. The decay also extended to the main trunk and eventually caused the death of tree s. Infected tissues of most diseased trees turned soft. This was found to be caused by *Ganoderma lucidum*. Other declining trees were resulted from invasion by *Kretzschmaria clavus* which formed black lines on infected tissues. *Ganoderma lucidum* grew faster and appeared to thrive at relatively high temperature in compars-ion with *K. clavus*.

Key words: Tree decline, macada mia, root rot, *Ganoderma lucidum*, *Kretzschmaria clavus*.

Introduction

Slow decline of macadamia trees (*Macadamia integrifolia* Maiden & Betche) indicated by dieback of branches (Fig. 1-A) was noticed at puli in central Taiwan in 1982. About 80 out of 840 macadamia trees in the orchard showed various degrees of decline. Similar problem was reported in Hawaii in 1973 (7). The disease in Hawaii was originally thought to be due to deficiency of certain essential elements, but was subsequently found to be mainly due to root rot caused by *Kretzschmaria clavus* (Fr.) Sacc. of Xylariaceae (5). We report here the factors causing the macadamia decline in Taiwan.

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②Chia-yi Agricultural Experiment Station, TARI, Chia-yi, Taiwan, ROC;

③Department of Plant Pathology, Beaumont Agricultural Research Center, University of Hawaii, Hilo, Hawaii 96720, USA

Isolation

Materials and Methods

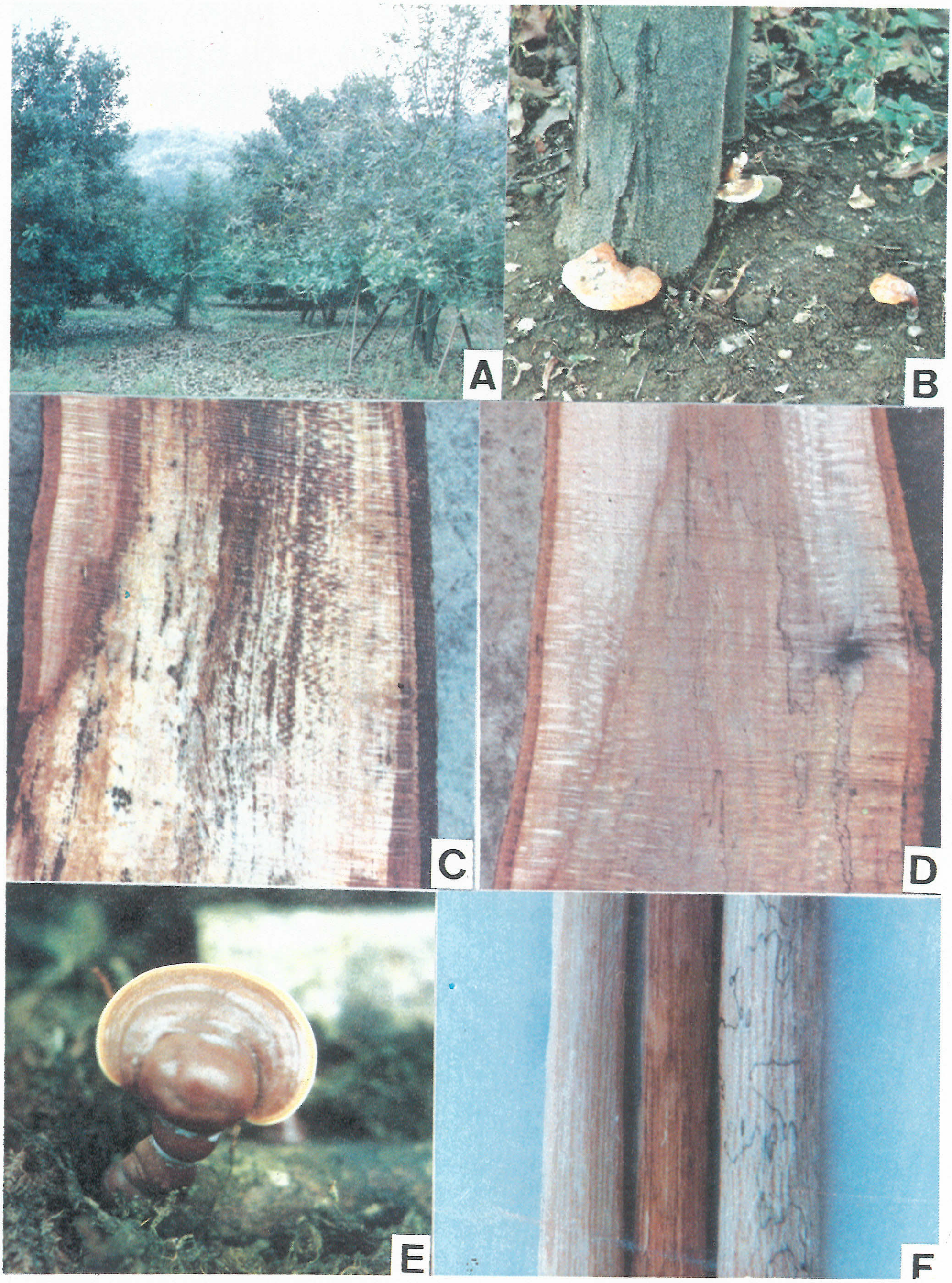

Fig. 1. Root rot of macadamia. (A). Unthrifty appearance of root rot affected tree (right). (B). Fruiting bodies of *Ganoderma lucidum* from infected root and trunk of macadamia tree. (C). Symptoms on macadami atrunk infected by *G. lucidum*. Note the whitis h and dark brown appearance in infected area. (D). Symptoms on macadamia trunk infected by *Kretzschmaria clavus*. Note the black lines ini nfected area. (E). A fruiting body of *G. lucidum* produced on an autoclaved litchi stem section. (F). Macadamia stems artificially infected with *G. lucidum* (center) and *K. clavus* (right). Stem on left is a control.

Discolored trunk tissue samples (ca. 5×2×1mm) taken immediately adjacent to healthy tissues were surface-sterilized with 0.5% sodium hypochloride solution for 3 min and placed on potato dextrose agar (PDA). Six pieces of tissues were placed on each plate and incubated at 24 C. The fungus growing from the diseased tissues were transferred to water agar (2% Bacto agar). Single hyphal tips obtained from the fungus growing on water agar were cultured and maintained on PDA.

Pathogenicity tests

The wheat-oat medium which rendered *K. clavus* very effective in causing disease on branches and seedling stems of macadamia (4, 6) was used to grow isolated fungi for pathogenicity tests. The fungi were grown on wheat-oat medium (10g whole wheat grains, 10g whole oat grains and 10ml distilled water) for 1 month at 24C. Macadamia branches (10-15mm diam.) were surface disinfected with 75% ethanol and scraped gently to remove the epidermis from bark tissues. About 10g of colonized grains were placed on the scraped portion of the branch, wrapped with transparent polyethylene plastic sheet and secured with vinyl tape. Scraped branches similarly i noculated with autoclaved grains were used as controls. Each treatment consisted of 25 branches from 5 macadamia trees. Data were recorded 3 and 6 months after inoculation.

Pboductuon of fruiting bodies

The method developed by Ko (2) was used for production of peritheical stromata by *K. clavus* and basidiocarps by *Ganoderma lucidum* (W. Curt. ex Fr.) Karst. Auto-claved sections of macadamia or litchi branches (ca. 10cm long and 3-4cm in diam.) in glass jars were inoculated with culture of *K. clavus* or *G. lucidum*. After incubation for 1-2 months at 24C, colonized tissues were placed on natural soil in plastic containers (24×18×5cm) and maintained moist by placing moistened sphagnum moss around them. Plastic containers were placed in the greenhouse and watered daily.

Gbowth of fungi

G. lucidum and *K. clavus* were grown on PDA for 3-5 days at 24C. Agar discs (5 mm in diam.) cut from the periphery of the colonies with a sterile cork borer were used to inoculate plates. To determine the effect of temperature on growth of fungi, inoculated PDA plates were incubated at 10, 15, 20, 25, 30 and 35C in darkness. Colonies were measured daily until the fungus reached the edge of the plate or 10 days after inoculation. Three plates were used for each treatment and the experiment was done two times.

Results

Symptoms

The disease is evidenced by slow decline, indicated by fading and dropping of leaves from branches (Fig. 1-A). The infected trees died eventually. About 80% of the diseased macadamia trees were associated with fruiting bodies produced by the fungus identified as *G. lucidum* of the Polyporaceae by T. T. Chang. Brown basidiocaps with stipe appeared on trunk near the soil line or on the ground near the trunk of a diseased tree (Fig. 1-B). Most of roots were decayed and the decay extended into the main

trunk. The color of infected tissue changed from light brown to dark brown as the disease progressed. Eventually the texture of the diseased tissue became soft and the color turned whitish (Fig. 1-C).

The other 20% of the declining macadamia trees were not associated with fungal fruiting bodies. However, most of the roots of these trees were also decayed and the decay extended into the main trunk in the later stage of the disease development. The disseased tissue turned brown, showed distinct black lines, and remained firm and hard (Fig. 1-D) similar to that caused by *K. clavus* (5).

Pathogenicity tests

A fungus producing colony which appeared whitish at the begining and turned yellowish later on PDA, was consistently isolated from tissues of diseased plants associated with fungal fruiting bodies. The fungus was identified as *G. lucidum* because it produced fruiting bodies indistinguishable from those produced by *G. lucidum* (Fig. 1-E) on colonized litchi and macadamia branches after incubation on soil for 1 month. The percentage of macadamia branches killed by *G. lucidum* was 40 and 80% after inoculation for 3 and 6 months, respectively (Table 1). Infected tissues turned brown (Fig. 1-F) just like those observed in nature. *G. lucidum* was reisolated from all the artificially infected branches. Control branches remained healthy. The fungus also did not infect branches without wounding.

Table 1. Pathogenicity of *Ganoderma lucidum* and *Kretzschmaria clavus* on macadamia branches.

Fungus	Disease incidence (%) after			
	3 months		6 months	
	Inoculated	Control	Inoculated	Control
G. lucidum	40	0	80	0
K. clavus	20	0	60	0

The fungus consistently isolated from diseased tissues with black lines was very slow in growth. Colonies produced by the fungus on PDA were grayish black on the surface behind the white advancing margin. The fungus developed blackish sterile stromatic aggregates below the surface causing the colonies to crack frequently. These characteristics were similar to those expressed by *K. clavus* (5). The fungus produced relatively large effused carbonaceous stromata on colonized branches of litchi and macadamia after incubation on soil for 2 months. The fungus was identified as *K. clavus* because these perithecial stromata were indistinguishable from hypoxyoid stromata produced by *K. clavus* (3). The percentage of macadamia branches killed by *K. clavus* was 20 and 60% after inoculation for 3 and 6 months, respectively (Table 1). The fungus produced black lines on the infected tissues similar to those observed in nature. *K. clavus* was reisolated from all artificially infected branches. The fungus also did not infect branches without wounding.

Growth of fungi

The growth rate of *G. lucidum* was much higher than that of *K. clavus* at 25C, *G. lucidum* grew 8.6mm/day, while *K. clavus* grew only 1.7mm/day (Fig. 2). *G. lucidum* appeared to thrive at relatively high temperature in comparison with *K. clavus*. The optimum temperatures for *G. lucidum* and *K. clavus* were 25-30C and 20-25C, respectively. The minimum temperature for both fungi was about 10C. *K. clavus* was not able to grow at 30C. However, even at 35C *G. lucidum* grew about 3 mm/day.

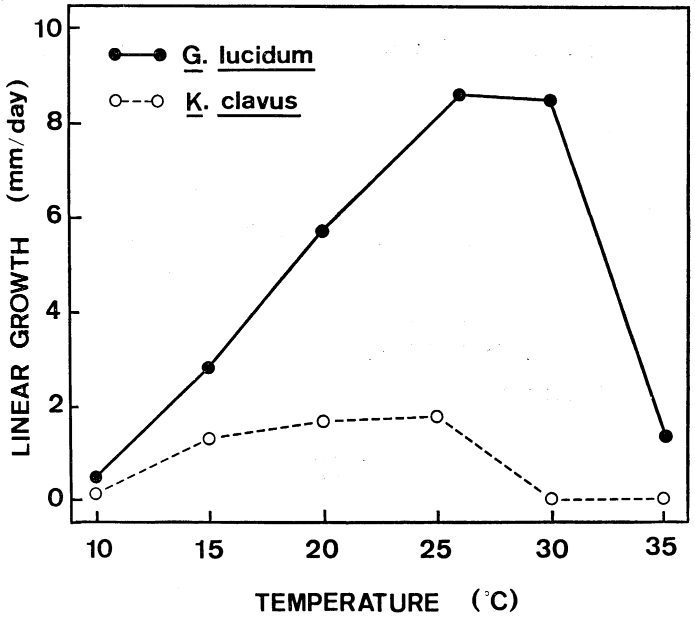

Fig. 2. Growth rate of *Ganoderma lucidum* and *Kretzschmaria clavus* on potato dextrose agar.

Discussion

Our data show that root rot caused by *G. lucidum* is the major cause of decline of macadamia trees in central Taiwan. Only about 20% of the declining macadamia trees in this area were caused by *K. clavus* root rot. This is quite different from that occurring in Hawaii where *K. clavus* root rot is the major cause of macadamia decline. A macadamia tree infected by both *G. lucidum* and *K. clavus* had not been observed at Puli.

G. lucidum has a relatively wide range of temperature suitable for its growth. The fungus also has a very broad geographical distribution (1). Therefore, *G. lucidum* root rot may occur frequently when macadamia cultivation is further expanded world wide in the future.

In Hawaii, *K. clavus* also attacked trees in the forest by the macadamia orchard with the decline problem (6). This appeared to be the main source of inoculum. The sources of inoculum of *G. lucidum* and *K. clavus* for macadamia orchard at Puli are still unknown.

Acknowledgments

We thank T. T. Chang for the identification of *Ganoderma lucidum.*

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Ganoderma lucidum 及 *Kretzschmaria clavus* 在臺灣引起之澳洲胡桃根腐病[1]

安寶貞[2] 柯文雄[3]

摘要

在埔里地區，由於根腐病之蔓延，約有10%之澳洲胡桃顯現不同程度之枯萎。而且這種組織腐敗擴展至主幹，最後引起樹木死亡。

大部份染病的澳洲胡桃組織軟化，證實系由靈芝 *Ganoderma lucidum* 感染所致。另有部份衰敗的植株，則因 *Kretzschmaria clavus* 侵入之故，病菌並在木材上形成黑色線紋，但組織並不軟化。與*K. clavus*相較，*G. lucidum*生長較快速，且偏好高溫。

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2.臺灣省農業試驗所嘉義分所植保系副研究員。臺灣省 嘉義市。

3.美國夏威夷大學植病系。希羅 夏威夷。

中華農業研究 (Jour. Agric. Res. China) 37(4)：430～439 (1988)

柑橘木蝨之生物防治

1.亮腹釉小蜂 (*Tamarixia radiata*) 之引進繁殖與釋放試驗[1]

錢景泰　邱瑞珍　古琇芷[2]

摘要：柑橘木蝨 (*Diaphorina citri*) 爲柑橘立枯病之媒介昆蟲，法屬留尼旺島曾利用亮腹釉小蜂 (*Tamarixia radiata*) 防治柑橘木蝨，成效卓著。省農業試驗所爲減少木蝨的傳病機會，從該島引進該寄生蜂。經室內檢疫與增殖後，於民國 73 至 77 年共繁殖該釉小蜂 21,164 隻，分別在農試所甜橙以及臺灣 12 縣市共 39 處月橘綠籬上釋放。目前亮腹釉小蜂已在全省立足。其對於本省木蝨寄生情形以臺中地區爲最好，其寄生率顯著超越木蝨本地天敵，紅腹跳小蜂 (*Diaphorencyrtus diaphorinae*)。釉小蜂在本省其他釋放地區也十分活躍，受本地重複寄生蜂之影響不超過 1.0 %。

柑橘木蝨 (*Diaphorina citri* Kuwayama) 爲害柑橘除直接吸食嫩芽或嫩葉外，且分泌蜜露誘發煤病。Huang 等氏更證實其能傳播本省柑橘立枯病[6]，嚴重影響柑橘生產。本省對此害蟲之防治一向以藥劑爲主，管理良好之橘園，木蝨族群密度發生均低，其爲害多集中在柑橘之春、夏、秋芽期。另外在月橘 (*Murraya paniculata* Linn.)、黃皮 (*Phellodendron chinense* Schneid) 及一些芸香科植物上，木蝨也可繁衍[1]。因此，普遍作綠籬用月橘和疏於管理以及廢耕之柑橘園，便成爲木蝨孳生溫床和柑橘立枯病之傳播站。柑橘木蝨之本地產天敵有安平草蜻蛉 (*Chrysopa boninensis* Okam.)、六條瓢蟲 (*Menochilus sexmaculatus* Fabr.) 以及紅腹跳小蜂 (*Diaphorencyrtus diaphorinae* (Lin & Tao))[1]。春季木蝨族群激增時，二種捕食性天敵族群上升緩慢，因此無法控制柑橘木蝨之爲害[1]。法屬留尼旺島 (Reunion Is.) 利用亮腹釉小蜂 (*Tamarixia radiata* (Waters.)，Eulophidae)[4] 防治柑橘木蝨，寄生率高達 92.5%，成效卓著[3]。筆者等有鑑於此，於72年12月 9 日自留尼旺島果樹農業試驗所 (Institut de Recherches sur les Fruits et Agrumes)，將該蜂引進本省，經過室內檢疫與飼育繁殖後並釋放於甜橙 (*Citrus sinensis*) 與月橘上防治柑橘木蝨。

材料與方法

亮腹釉小蜂之引進：Aubert 博士在法屬留尼旺島利用盆栽月橘苗飼育柑橘木蝨若蟲，在無重複寄生之環境下，繁殖亮腹釉小蜂。並用航空郵件寄達農試所供試。

亮腹釉小蜂之大量繁殖：在溫室栽植廣東檸檬 (*Citrus limonia* Osbeck) 苗木 800 盆作爲柑橘木蝨之寄主植物，每週定期修剪 200 盆苗木，促使其萌發新芽，待新葉展開生育茂盛時移入室溫 25±1°C 室內飼育木蝨若蟲。另在田間栽種月橘綠籬 (25×1m) 3 排，經常修剪，使新芽萌發，

1.臺灣省農業試驗所研究報告第　1437　號。

2.臺灣省農業試驗所助理研究員、前研究員、計畫助理。臺灣省　臺中縣　霧峰鄉。

誘引柑橘木蝨前來產卵。每日將產有木蝨卵之月橘枝條剪回，除去側生枝葉，只剩枝梢有卵之芽條，放入盛水之塑膠杯（9.5×4.5 cm）內，移置 25°C 生長箱。待木蝨卵孵化為1～2齡若蟲時，將帶有若蟲之芽段放在盆栽廣東檸檬苗上，使木蝨自動遷移至苗上繼續發育至第5齡若蟲時，再用兩端開口，一端覆以 1,764 meshes 尼龍網之透明塑膠筒（22×11.8 cm）罩住，並將300隻木蝨與 15 或 20 隻寄生蜂（即 20 或 15 比1）之比率接入亮腹釉小蜂， 24 小時後將蜂移出，重新更換寄主供其產卵寄生。接蜂後第5日被寄生之木蝨變成乾屍（Mummy），再經4日後即可收集自乾屍羽化出之釉小蜂。

亮腹釉小蜂之釋放：釉小蜂最初係在農試所甜橙園內釋放，因發現柑橘木蝨之發生頗受柑橘春、夏、秋芽期之限制，若蟲無法終年在柑橘上存活，為增加引進寄生蜂釋放後之成功機會，乃改在月橘綠籬上進行。其釋放方法一為網罩式，一為直接放蜂。前式在農試所、萬豐及霧峰等地選定有第5齡木蝨若蟲為害之月橘枝條，用兩端開口之細密尼龍網（60×44 cm，1,764 meshes）罩住。先收緊網下方之開口，將蜂引入後再將其上方之開口收緊，2天後將網罩取下。較遠地區，因恐月橘枝條長期罩網，會影響植株生長與木蝨發育，因此直接將蜂釋放在有木蝨第5齡若蟲為害之月橘上。

亮腹釉小蜂之立足與分散：釉小蜂在各釋放點之立足情形，係以放蜂後7～15 天或1個月後在原釋放蜂之枝條或地點，檢視木蝨被該蜂寄生之乾屍與寄生蜂已羽化之空殼，並持續觀察該蜂在自然環境下之增殖情形，以確定其立足與否。各地調查時間因地點之遠近而不同，如臺中地區每7天1次，彰化地區每 14 天1次，嘉義與高雄及屏東地區則每 30天1次。自76年2月開始釉小蜂在全省各地分散之追蹤調查，以臺中為中心，沿西部縱貫線分赴南北各地未放蜂地區，調查月橘綠籬上有無被釉小蜂寄生之木蝨乾屍。同年9月與 11 月更遠赴東部，調查宜蘭與花蓮、臺東等地月橘上之釉小蜂寄生情形。

亮腹釉小蜂與本地紅腹跳小蜂之競爭：亮腹釉小蜂釋放本省田間後其與本地紅腹跳小蜂間之族羣消長情況，係依據月橘上木蝨被兩種蜂寄生而尚未羽化之乾屍數比例予以評定。木蝨被亮腹釉小蜂寄生之乾屍，體扁平，暗褐色，體周邊有白色絲狀物固著植物表面，羽化孔位於其胸部背面。被紅腹跳小蜂寄生之乾屍，體呈半球形隆起，紅褐色，羽化孔位於木蝨乾屍腹部背面。

重複寄生蜂對木蝨寄生蜂之影響：在臺中、彰化、雲林、嘉義、臺南、高雄及屏東等地月橘上採集被紅腹跳小蜂與亮腹釉小蜂寄生之木蝨乾屍，攜回室內飼育並記錄所羽化出之重複寄生蜂種類與寄生率，以瞭解重複寄生蜂對前述兩種木蝨寄生蜂之影響。

結　果

亮腹釉小蜂之引進：亮腹釉小蜂經法屬留尼旺島實驗室繁殖後寄達臺灣省農業試驗所供試。自民國 72 至 75 年共引進4批。首批於 72 年 12 月9日收到，成蜂在寄遞途中全部死亡， 73 年2月 13 日改用被釉小蜂寄生之木蝨乾屍寄遞，到達時有6雌，4雄活著 ，於是在農試所天敵檢疫室進行該蜂之檢疫、飼育及增殖。並釋放於農試所甜橙園，但自7月份起因氣溫上升，木蝨若蟲期較短，且羽化之成蟲迅速飛散，因此釋放後之釉小蜂在缺乏適當寄主之情況下無法繼續繁殖。73 年 10 月 19 日再次引進5雌，6雄釉小蜂，經檢疫增殖後，除部分供釉小蜂之生物學研究外，其餘則分批釋放田間。74 年 12 月至 75 年1月發現室內之釉小蜂經累代飼育至 21 代後，其繁殖率由 25 倍降為1倍，成蜂僅能活1天。於是 75 年5月 14 日引進第4批釉小蜂，計雌蜂 32 隻、雄蜂9隻。

亮腹釉小蜂之釋放與立足：亮腹釉小蜂自 73 年引進臺灣後，於同年5～6月、11～12 月及 74 年3月，在農試所甜橙園用網罩式釋放成蜂 15 次，計 593 隻。僅在放蜂後7～15 天，放蜂枝條上發現被寄生之木蝨乾屍，寄生率為 0～36.4％，但此後未再發現。74 年3～5月與 11 月，分別將 1,509 隻與 195 隻釉小蜂分批釋放於農試所與萬豐派出所之月橘綠籬上， 兩地在釋放後7～15天，均有被寄生之木蝨乾屍被發現 ，且後者平均寄生率為 12.9％（ 0-28.9 ％）。但仍未能確定其已經立足。至 75 年3月採集木蝨若蟲時，竟在萬豐派出所月橘上首次回收到釉小蜂寄生木蝨之乾屍，寄

生率爲 16.8 %，此時才認爲該蜂可望在臺灣立足。繼將田間回收之釉小蜂在室內增殖，且於 75 與 76年分別在霧峰、田尾、烏山頭、大埔、澄清湖、屛東農專、高雄區農業改良場、麟洛及潮州等地陸續釋放 9 次，計 714 隻。結果發現僅釋放十餘隻，多至百餘隻，經過 1 ～ 5 個月就可在各釋放點採到木蝨被該蜂寄生的乾屍（表 1）。追蹤調查時，發現該蜂已分散至其他地區（表 2，圖 1）。爲謀加速釉小蜂在臺灣之立足與分散，筆者等繼續在已經發現有釉小蜂分布的 12 縣市 39 地點的月橘綠籬上釋放釉小蜂。總計自 73 年 5 月至 77 年 6 月共釋放 184 次，共約 21,164 隻蜂（表 3）。

表 1. 亮腹釉小蜂之釋放與回收日期

Table 1. The release and recovery dates of *Tamarixia radiata* in Taiwan

地 點 Sites	釋放日期 Date of release	放蜂數 No. parasitoids released	回收日期 Date of 1st recovery	寄主植物 Host plant
臺中：農試所	May 1984-Mar. 1985	593	Aug. 1986	甜橙
農試所	Mar.-May 1985	1,509	Sept. 1986	月橘
萬 豐	Nov. 1985	195	Mar. 1986	月橘
霧 峰	May 1986	236	Aug. 1986	月橘
彰化：田 尾	May 1986	134	Aug. 1986	月橘
臺南：烏山頭	Oct. 1986	84	Mar. 1987	月橘
嘉義：大 埔	Feb. 1987	12	Mar. 1987	月橘
高雄：澄清湖	Feb. 1987	53	Mar. 1987	月橘
屛東：屛東農專	Feb. 1987	25	Mar. 1987	月橘
高雄農改場	Feb. 1987	26	May 1987	月橘
麟 洛	Apr. 1987	112	Jun. 1987	月橘
潮 州	Apr. 1987	32	Sept. 1987	月橘

表 2. 引進亮腹釉小蜂在本省之立足點

Table 2. The established localities of the introduced *Tamarixia radiata* in Taiwan

調查日期 Date of survey	立足地點 Established localities
Mar. 1986	臺中（萬豐）
Aug.	臺中（霧峰）、南投（中興新村）
Oct.	彰化（員林，永靖，田尾）、南投（草屯）
Feb. 1987	臺中（臺中市，后里，外埔）、南投（埔里）、嘉義（竹崎，中埔）、臺南（烏樹林）
Mar.	南投（名間）、彰化（彰化市，二水）、雲林（林內，斗六，斗南）、嘉義（嘉義市，民雄，梅山，水上，大埔）、臺南（白河，東山，新營，柳營，烏山頭）、高雄（澄清湖）、屛東（屛東農專）
Apr.	臺中（大甲，清水，沙鹿）、苗栗（竹南，後龍，通霄，苑裡）、新竹（新竹市，新豐，新埔，香山）、高雄（旗山，大樹）
May	苗栗（頭份，銅鑼）、桃園（龜山，桃園市，內壢，中壢，楊梅）、臺北（公館，三重，新莊，樹林）、屛東（高雄區農業改良場）、臺東（臺東市）
Jun.	屛東（麟洛，內埔）、臺北（泰山）
Aug.	屛東（林邊，恆春）
Sept.	宜蘭（宜蘭市，二城，礁溪）、臺北（景美）
Nov.	花蓮（花蓮市，天祥，吉安，壽豐，鳳林，光復，瑞穗，玉里）、臺東（成功，新港，都歷，泰源，東河，都蘭）

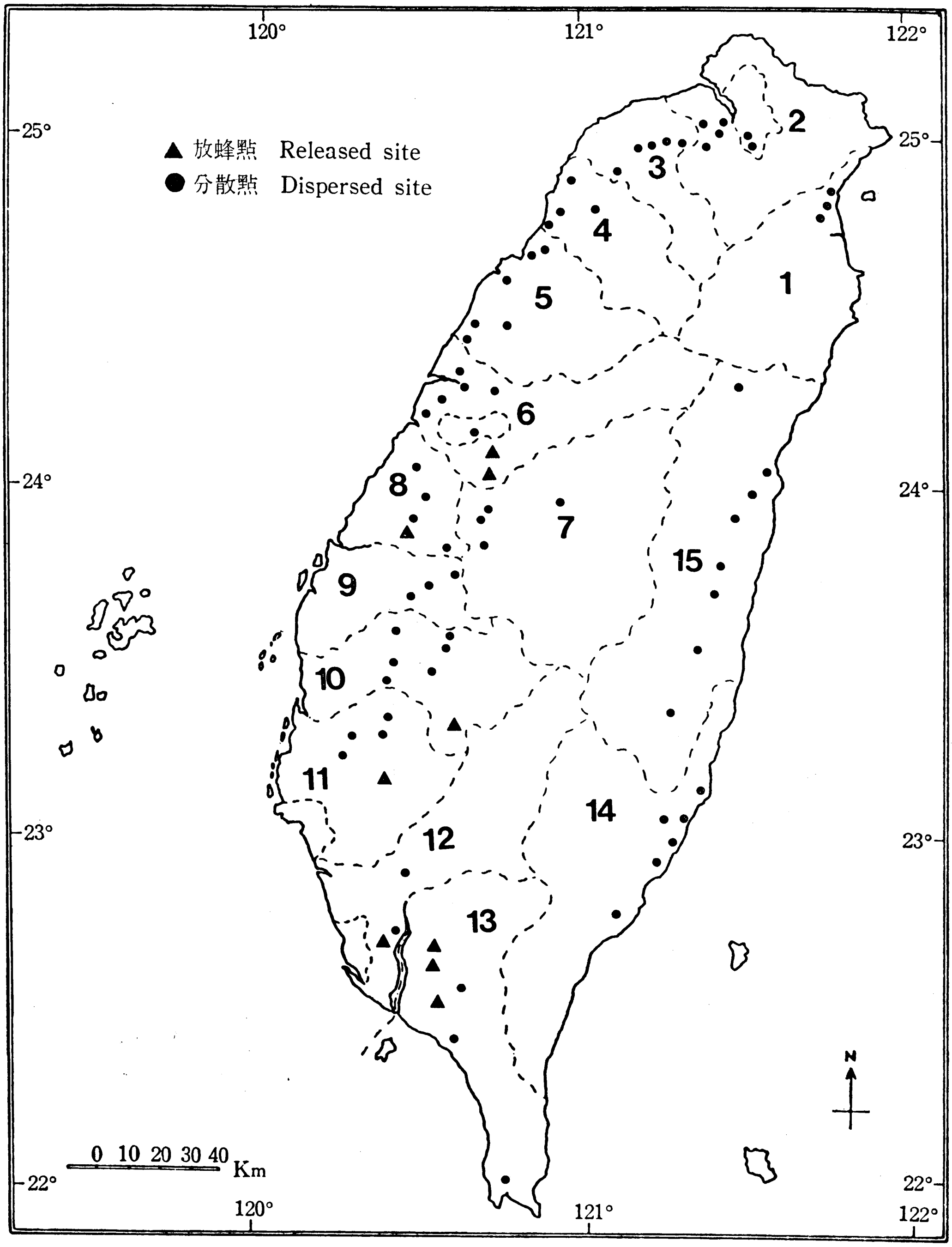

圖 1. 亮腹釉小蜂釋放與分散圖

Fig. 1. Map of the released and dispersed sites of *Tamarixia radiata* in Taiwan

1. 宜蘭 (Ilan) 2. 臺北 (Taipei) 3. 桃園 (Taoyuan) 4. 新竹 (Hsinchu)
5. 苗栗 (Miaoli) 6. 臺中 (Taichung) 7. 南投 (Nantou) 8. 彰化 (Changhua)
9. 雲林 (Yunlin) 10. 嘉義 (Chiayi) 11. 臺南 (Tainan) 12. 高雄 (Kaohsiung)
13. 屏東 (Pingtung) 14. 臺東 (Taitung) 15. 花蓮 (Hualien)

表 3. 73 年5月至 77 年6月亮腹釉小蜂在各地之總釋放數

Table 3. Total number of *Tamarixia radiata* released at different localities from May 1984 to June 1988 in Taiwan

釋放地點 Released localities	釋放次數 No. of release	釋放蜂數 No. parasitoids released	寄主植物 Host plant
宜　蘭	4	340	月橘
臺　北	3	281	月橘
桃　園	1	22	月橘
新　竹	3	85	月橘
苗　栗	2	49	月橘
臺　中	83	9,679	月橘，甜橙
南　投	1	23	月橘
彰　化	24	3,675	月橘
雲　林	5	287	月橘
嘉　義	14	1,351	月橘
臺　南	4	202	月橘
高　雄	13	1,283	月橘
屏　東	27	3,887	月橘
合　計	184	21,164	

亮腹釉小蜂之分散：亮腹釉小蜂引進臺灣初期之放蜂雖然失敗，但至75年 3 月31日該蜂首次在萬豐發現後，約隔 4 個半月，偶然在農試所甜橙園與距離放蜂區 9 公里之南投中興新村月橘上發現有釉小蜂寄生之木蝨乾屍，後者被寄生率約達 11.4 %。同年 5 月 17 日與 26 日在霧峰省議會與彰化田尾鄉放蜂，但未立即進行調查，隔 3～4 個月後，在霧峰街上與距田尾放蜂區約 3 至 9 公里之彰化縣永靖、員林等地亦發現有釉小蜂蹤跡，顯示釉小蜂已能自行分散。76 年 2 月至 11 月止，以臺中為中心進行全省釉小蜂分散之調查，得知隨著時日增加，釉小蜂能够由近而遠自各原釋放點逐漸擴散到其

表 4. 紅腹跳小蜂與亮腹釉小蜂之重複寄生蜂及其寄生率

Table 4. Hyperparasitoids and their percent of parasitism on *Diaphorencyrtus diaphorinae* and *Tamarixia radiata* form May 1985 to May 1988 in Taiwan

重複寄生蜂 Hyperparasitoids	寄生率 Parasitism (%) *D. diaphorinae*	 *T. radiata*
Pteromalidae		
Pachyneuron concolor	18.50	0.45
Signiphoridae		
Chartocerus walkeri	13.50	0.03
Aphelinidae		
Encarsia sp. near *shafeei*	0.80	0.11
Coccophagus ceroplastae	0.01	0.00
Coccophagus sp.	0.10	0.00
Marietta leopardina	2.50	0.25
Unidentified	0.01	0.05
Encyrtidae		
Syrphophagus taiwanus	6.80	0.05
Cheiloneurus sp.	0.01	0.00
Ageniaspis sp.	0.01	0.00
Eulophidae		
Tetrastichus sp.	0.00	0.01
Total	42.22 (14,319)	0.95 (11,342)

他地區（表2）。表2所載之釉小蜂分散日期係以筆者等調查月份爲準，釉小蜂極可能早在筆者等調查前已分散到各地。

亮腹釉小蜂與紅腹跳小蜂之競爭：臺中地區釉小蜂釋放時期較早、且在放蜂量較多之情形下，目前該蜂已穩定地占最優勢。彰化地區則顯示跳小蜂占優勢，但在2至5月間跳小蜂發生較少之月份，釉小蜂仍能發揮其寄生效果。至於嘉義地區，則兩蜂互有消長，高雄與屏東地區，仍以跳小蜂占優勢（圖2）。

重複寄生蜂對木蝨寄生蜂之影響：依據73年11月至77年3月本省中部地區之調查結果，得知紅腹跳小蜂在月橘與柑橘上均十分活躍。6～12月該蜂在月橘上對木蝨之寄生率維持在15～56.9％，1至5月之寄生率則低於15.1％。尤其3至4月木蝨族羣激增，其寄生率爲0。同時發現該蜂有被寄生之現象，一般寄生率爲25～70.0％，74年12月與75年1月竟高達88％（圖3）。木蝨之重複寄生蜂種類多達11種，但以金小蜂 *Pachyneuron concolor* Förster.、橫盾小蜂 *Chartocerus walkeri* Hayat 及臺灣蚜虻跳小蜂（*Syrphophagus taiwanus* Hayat & Lin）較爲重要[5]（表4）。依據臺中、彰化、雲林、嘉義、臺南、高雄及屏東等地採得紅腹跳小蜂之寄生蜂類，發現金小蜂、橫盾小蜂及臺灣蚜虻跳小蜂發生較多，可視爲各地共有種。嘉義以南，矮蜂 *Marietta leopardina* Motschulsky 崛起形成臺灣南部木蝨之重要重複寄生蜂(表5)。74年5月至77年5月在全省共採得紅腹跳小蜂寄生的木蝨乾屍14,319個，其中42.2％被10種寄生蜂重複寄生。而亮腹釉小蜂在引進時雖然已經過隔離

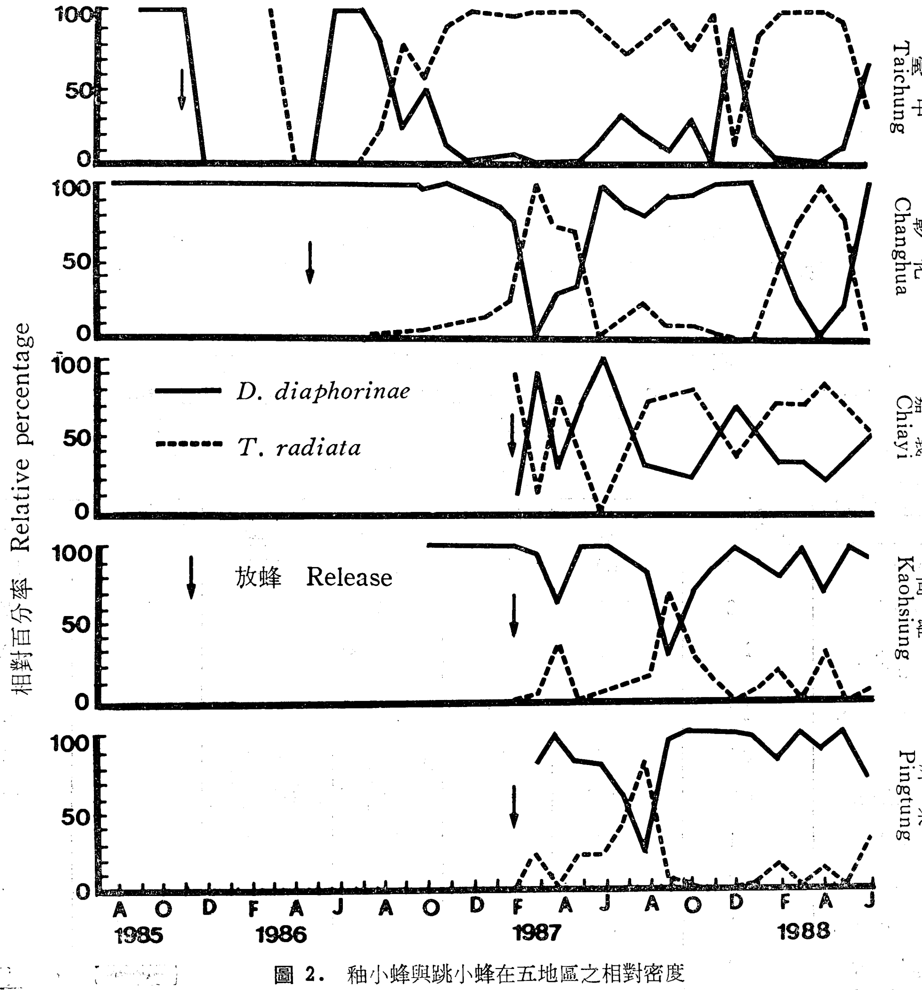

圖2. 釉小蜂與跳小蜂在五地區之相對密度

Fig. 2. The relative density of *Tamarixia radiata* and *Diaphorencyrtus diaphorinae* in five areas of Taiwan

檢疫，未將寄生蜂帶入臺灣，但自75年9月至77年5月在全省採得亮腹釉小蜂寄生的木蝨乾屍11,342個，竟發現有1.0% 遭受7種本地重複寄生蜂寄生（表4）。

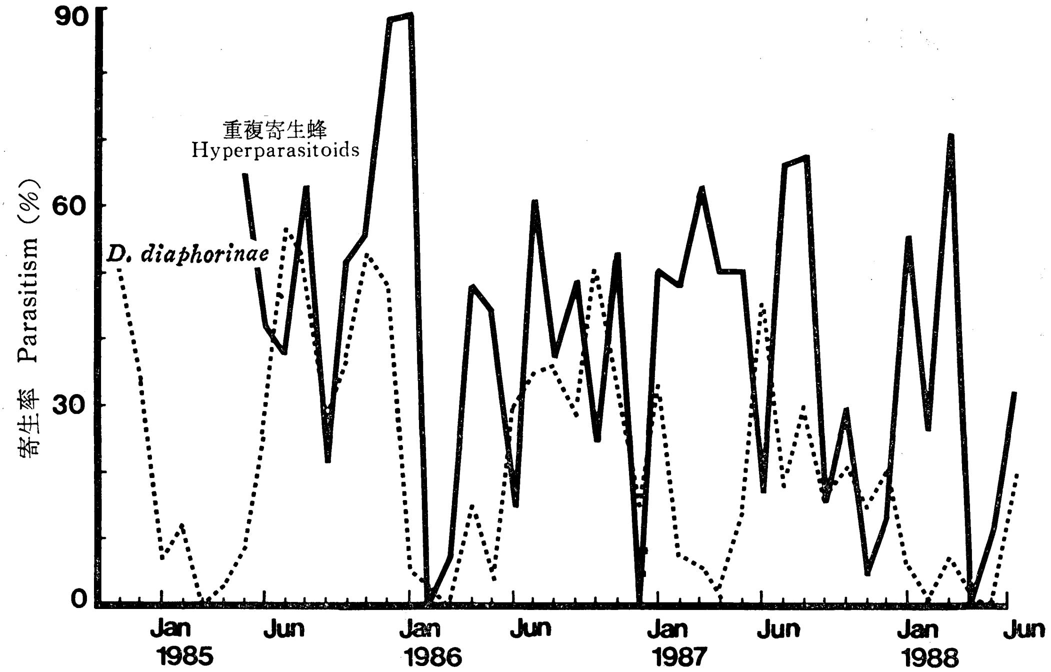

圖 3. 中部地區月橘上紅腹跳小蜂與其重複寄生蜂之發生消長

Fig. 3. Population fluctuation of *Diaphorencyrtus diaphorinae* and its hyperparasitoids in central Taiwan

表 5. 不同地區紅腹跳小蜂之重複寄生蜂類及其寄生率

Table 5. Hyperparasitoids and percent parasitism on *Diaphorencyrtus diaphorinae* at different localities of Taiwan from May 1985 to May 1988

重複寄生蜂 Hyperparasitoids	寄生率 Parasitism (%)						
	臺中 Taichung	彰化 Changhua	雲林 Yunlin	嘉義 Chiayi	臺南 Tainan	高雄 Kaohsiung	屏東 Pingtung
P. concolor	16.3	19.0	21.0	47.7	11.9	13.2	13.6
Ch. walkeri	14.6	14.1	0.8	6.0	17.6	16.0	7.3
Encarsia sp. near *shafeei*	1.0	0.7	0.0	1.6	0.0	1.1	0.6
Coccophagus sp.	0.4	0.04	0.0	0.0	0.0	0.0	0.2
C. Ceroplastae	0.1	0.0	0.0	0.0	0.0	0.0	0.0
M. leopardina	0.7	0.06	0.0	9.5	40.3	12.9	14.9
Unidentified	0.1	0.0	0.0	0.0	0.0	0.0	0.0
S. taiwanus	2.5	8.5	0.03	4.3	2.5	4.5	2.5
Cheiloneurus sp.	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Ageniaspis sp.	0.05	0.0	0.0	0.0	0.0	0.0	0.0
Total mummies	2,133	9,885	129	304	159	536	1,223

討論與結論

亮腹釉小蜂引進臺灣後，初期的表現雖甚不理想，但目前似已適應臺灣之冬季低溫、春季梅雨及夏秋颱風豪雨等之襲擊，且能穩定立足與快速擴散。更由於釉小蜂之發生較早，能在每年5月以前紅腹跳小蜂發生少時，先行發揮其對木蝨若蟲族羣之抑制。又因釉小蜂受本地木蝨重複寄生蜂之寄生率目前僅1.0％，顯示該蜂可以增强臺灣木蝨生物防治之陣容。至於該蜂能否顯著發揮對月橘上柑橘木蝨族羣之抑制，與紅腹跳小蜂之長期競爭結果爲何，以及是否會受本地重複寄生蜂之影響，則須進一步探討。

一般比較兩種寄生蜂在田間之競爭力係將寄主若蟲（或幼蟲）攜回室內飼育，觀察並計算其被寄生蟲數，並用兩蜂被寄生率表示之。但就比較臺中地區亮腹釉小蜂與紅腹跳小蜂之寄生能力時，依據田間釉小蜂與跳小蜂之寄生木蝨乾屍數比例，則釉小蜂極佔優勢，約55.6～100％。但依採回木蝨第五齡若蟲之寄生率估算時往往釉小蜂遠不如跳小蜂（表6）。探究原因可能由於釉小蜂乃寄生於木蝨體外，當木蝨被迫遷移活動時，可使釉小蜂幼蟲脫落，影響調查寄生率之準確度，因此評估釉小蜂之寄生能力，應以在田間已經形成而尚未羽化之木蝨乾屍數爲判定標準。

亮腹釉小蜂引進臺灣釋放後，在3年6個月內（73年5月至76年11月）即分散全島，因而引起部分學者對該蜂之立足與分散表示懷疑，彼等所持之唯一理由，爲難以相信該蜂之遷移分散能力，臺

表 6. 不同取樣法對兩種木蝨寄生蜂寄生能力估算之影響

Table 6. Effect of sampling methods for estimation of parasitism of *Diaphorencyrtus diaphorinae* and *Tamarixia radiata*

調查日期 Date	取樣若蟲 Sampling nymph			取樣乾屍 Sampling mummy		
	蟲數 No. of insect	寄生率 Parasitism (%)		*diaphorinae* + *radiata*	相對百分率 Relative percentage	
		diaporinae	*radiata*		*diaphorine*	*radiata*
Sept. 1986	498	9.6	29.9	955	11.0	89.0
Oct.	4,031	44.6	3.1	804	44.4	55.6
Nov.	1,431	15.4	0.0	1,248	12.3	87.7
Dec.	2,273	10.4	0.0	796	0.0	100.0
Jan. 1987	755	17.4	2.1	1,434	2.1	97.6
Feb.	1,866	3.5	27.3	1,019	2.5	97.5
Mar.	3,719	6.8	17.1	2,773	0.0	100.0
Apr.	1,319	0.0	9.6	872	0.0	100.0
May	77	0.0	12.9	450	0.0	100.0
Jun.	254	7.9	0.0	291	13.1	96.9
Jul.	75	28.0	6.7	165	30.3	69.7
Aug.	1,553	18.2	11.4	778	20.3	79.7
Sept.	936	17.0	6.6	579	7.1	92.9
Oct.	375	8.0	7.2	661	27.4	72.6
Nov.	277	6.7	5.1	781	2.3	97.7
Dec.	1,167	20.1	0.1	182	84.6	15.4

灣可能在引進該蜂之前，已有釉小蜂存在。關於此點筆者等因未進行釉小蜂之遷飛試驗，故未能提供確切證據，但根據筆者等搜集之文獻，田間採集之經過及室內試驗，引述下列 6 點提供認定該蜂是否早已分布臺灣西部之參考。

1.文獻：林等 (1973) 在臺北公館之 6 年生桶柑，2 年生高接福木及綠籬月橘；蔡等 (1984) 在屏東九如綠籬月橘，分別定期調查木蝨各蟲期之發生消長，為期一年 (前者每 7 天 1 次，後者每30天 1 次)。當時僅發現木蝨寄生蜂 1 種即紅腹跳小蜂。

2.田間採集：筆者等自 73 年 11 月至 75 年 3 月在臺中與田尾地區綠籬月橘上採集 1 年 4 個月，共採得被紅腹跳小蜂寄生之木蝨乾屍 4,196 個，未曾發現亮腹釉小蜂 (圖 3)。74 年 11 月在臺中萬豐月橘上釋放釉小蜂，75 年 3 月才在當地回收。又 75 年 10 月至 76 年 4 月在南部各釋放點釋放釉小蜂前亦曾先調查當地月橘木蝨之被寄生情形，亦未發現釉小蜂蹤跡，而在釋放後 1 至 5 個月才發現該蜂 (表 1，圖 2)。圖 2 雖顯示嘉義地區 76 年 2 月釋放同時就發現釉小蜂，其原因是嘉義地區包括了竹崎、中埔及大埔等地。而筆者等在追蹤釉小蜂分散時，於 76 年 2 月即發現該蜂已分布於竹崎與中埔兩地，可能係由 75 年 10 月臺南烏山頭釋放點擴散所致。又於 76 年 3 月前往烏山頭調查，果眞發現釉小蜂除已在該處立足外，並在嘉義與臺南一帶均有分布 (表 2)。

3.重複寄生蜂：一般言之，本地產之害蟲、天敵及其重複寄生蜂三者間常維持一均衡狀態，因此天敵之重複寄生現象常普遍存在且其被寄生率亦高。筆者等自 74 年至 77 年採得木蝨被本地天敵紅腹跳小蜂寄生乾屍 14,319 個，得重複寄生蜂 10 種，平均重複寄生率為 42.2%。反觀亮腹釉小蜂自75 年 3 月首次回收至77年 6 月共採得木蝨乾屍 11,343個，飼育得重複寄生蜂自 1 種增至 7 種，平均重複寄生率為 0.95 % (表 4)。不過 77 年 8 月在臺中霧峰一地採得釉小蜂寄生乾屍 2,375個，其重複寄生率已增至 6 % (錢，未發表資料)。此種現象是否意味天敵初引進一地時，受當地重複寄生蜂之影響較小，爾後隨其數量之增加，本地重複寄生蜂逐漸對其產生適應，致使重複寄生率增高。

4.被寄生之位置：木蝨產卵於寄主植物之芽部，若蟲初孵化後先在原處取食，至 2、3 齡才向枝條處遷移，至 4、5 齡時在枝幹固定取食。此時若被釉、跳兩蜂寄生，其乾屍之位置即是木蝨老熟若蟲為害之部位，兩蜂間並無不同。若是釉小蜂早已存在本省，相信定能採到。

5.苗木移植的人為傳播：寄生蜂之分散除藉其本身近距離之分散能力外，尚可憑藉氣流、寄主苗木等遠播各地。近幾年臺灣建築業蓬勃，月橘又廣泛做為綠籬，76 年 5 月筆者等曾在臺北三重新建公寓前，即在剛種植且根部尚包紮有稻草之月橘上，發現被釉小蜂寄生之木蝨乾屍為數頗多。

6.競爭：由室內觀察得知亮腹釉小蜂生殖力强、發育期短、及對寄主齡期有顯著偏好，因此不論釉、跳兩蜂同時產卵寄生於同一木蝨上，或跳小蜂先產卵寄生 7、8 天後，釉小蜂再產卵，此二種競爭之情況，待兩蜂發育至老熟幼蟲時，釉小蜂均取得優勢(錢、未發表)。又臺中地區月橘綠籬上亦顯示釉小蜂在釋放後 10 個月，該蜂之寄生率已較跳小蜂為强(圖 2)。因而筆者等懷疑若釉小蜂早已存在本省，則其發生數必較多，當不難採到，不至於在中部地區該蜂釋放前 1 年又 4 個月均未採到被該蜂寄生之木蝨乾屍。南部屏東地區釉小蜂之釋放，如麟洛與高雄區農改場須在釋放後 2～3 個月才發現釉小蜂寄生之木蝨乾屍，而潮州甚至須在放蜂後 5 個月才發現被釉小蜂寄生之木蝨乾屍。

對於宜蘭、花蓮、臺東等地亮腹釉小蜂之分散結果，因為在 76 年 5 月及 9 月前均無人進行當地柑橘木蝨天敵之調查工作，而筆者等在確認釉小蜂已在西部各地分布後，才試探性地進行東部地區該蜂之調查，不料第一次調查即發現亮腹釉小蜂之分布，所以對該蜂何時擴散至該地區，本文無法提出直接之說辭，有待進一步之探討。

誌　謝

本研究承行政院農業委員會補助部分經費〔74 農建-4.1-產植 30(1)，75 農建-7.1-糧 14(1)，76 農建-8.1-糧 64(4)，77 農建-4.1-糧 66（1-4）〕。本項工作進行時，承蒙美國夏威夷州農業廳賴博永博士協助引進釉小蜂。法屬 Reunion 果樹試驗所 B. Aubert 博士數度寄贈釉小蜂，提供試驗蟲源。林珪瑞、M. Hayat 及 D. I. Faroogi 等氏鑑定重複寄生蜂學名。謹此一併誌謝。

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Biological Control of Citrus Psylla, *Diaphorina citri*

1. The introduction, augmentation and release of *Tamarixia radiata*[1]

Ching-chin Chien, Shui-chen Chiu and Shiu-chih Ku[2]

The citrus psylla, *Diaphorina citri*, is a vector of citrus Likubin in Taiwan. It was reported to be effectively controlled by its nymphal parasitoid, *Tamarixia radiata* in Reunion Islands. Taiwan Agricultural Research Institute introduced the parasitoid from Reunion Islands for the control citrus psylla to reduce the transmission of citrus Likubin. A total of 64 adult parasitoids in 4 shippments was obtained from 1983 to 1986. Then totally 21,164 adults of *T. radiata* were propagated and released to 39 citrus orchards and common jasmine orange (*Murraya paniculata*) bushes in 12 counties during 1984—1988. Results revealed that *T. radiata* has successfully established in this island. *T. radiata* is significantly predominence over the indigenous, *Diaphorencyrtus diaphorinae* in central Taiwan. Fortunately, the hyperparasitism of the introduced parasitoid is bellow 1.0% at the present.

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1. Contribution No. 1437 from the Taiwan Agricultural Research Institute.
2. Assistant Entomologist、former Senior Entomologist and Project Assistant, respectively, of Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan, ROC.

中華農業研究 (Jour. Agric. Res. China) 37 (4) : 440~452 (1983)

Purification and Characterization of Glutathione-S-transferase from Diamondback Moth, *Plutella xylostella* L.[1]

Cheng, E. Y., D. F. Lin, C. S. Chiu, and C. H. Kao[2]

Abstract The glutathione-S-transferase (GSTase) had been suggested as a possible metabolic enzyme related to insecticide resistance in the diamondback moth (DBM), *Plutella xylostella* L.and other insects. Although the GSTase was studied in many insects, it had not been thoroughly investigated in the DBM. In this study, GSTase was purified either by the traditional protein purification method or the affinity chromatographic method. The affinity chromatographic method was proven to offer a much simpler purification procedure and resulted in higher yield and purer grade of GSTase. The purification factors of GSTase by the affinity chromatography are 32.1 and 24.9 for resistant and susceptible DBM strains. The total activity of GSTase is higher in the resistant DBM, which was agreed with the previous observation that the organophosphate-resistant DBM possessed 2—4 fold higher GSTase activity than the susceptible DBM. After affinity chromatographic purification, only a single protein band was obtained in the polyacrylamide gel electrophoresis study, and the GSTase activity staining indicated the active zone is close but not totally matched the location of protein band. The explanation is unknown and needs further investigation. The molecular weight of DBM larval GSTase was measured at 45,000—46,500 daltons compared to other standard calibration proteins in the gel filtration columns, and is similar to the molecular weight of GSTases in housefly.

Introduction

In the previous investigation of the diamondback moth (DBM), *Plutella xylostella* L., the glutathione-S-transferase (GSH-S-transferase or GSTase) was recognized as a possible metabolic enzyme for organophosphorus insecticides (Cheng et al., 1983 & 1984). This enzyme is involved in mercapturic acid formation by catalyzing the initial conjugation of xenobiotic compounds with GSH, and has been investigated in mammalian

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2. Senior entomologist, NSC project assistant, and research assistants respectively. Department of Applied Zoology, TARI, Wufeng, Taichung 41301, Taiwan, Republic of China.

tissues as well as in insects (Clark et al., 1986; Cochrane et al ., 1987; Habig et al., 1974; Jakoby, 1978; Motoyama and Dauterman, 1972 & 1975; Motoyama et al., 1977 & 1980; Oppenoorth et al., 1979; Ottea and Plapp, 1984).

In the DBM, the activity of GSTase increases rapidly from the 3rd instar to the 4th. In order to establish the technique for further investigation of GSTase in relation to insect physiology and insecticide resistance, the technique for the purification and characterization of this enzyme is explored.

Materials and methods

Diamondback moth

Susceptible strain: the native I-lan (IL) strain was used, which was first collected in Tou-chen (TC) of I-lan county in 1984 and has been kept in the laboratory ever since as the susceptible standard.

Resistant strain: the resistant strain was collected from Hsi-hu (HH), where vegetables grew year round. The insects were collected in 1987 for testing, and has been proven with high multiple resistance to all traditional insecticides.

Chemicals

Substrate used for GSTase assay was 1, 2-dichloro-4-nitrobenzene (DCNB) obtained from Tokyo Kasei; glycine, sucrose, riboflavin, Tris (hydroxymethyl) aminomethane, reduced glutathione (GSH), sulfobromophthalein-S-glutathione-agarose (BSP-GSH-agarose), bovine serum albumin (BSA) , cytochrome C (mol. wt. =12,400 daltons), carbonic anhydrase (mol. wt. =29,000 daltons), alcohol dehydrogenase (mol. wt. =150,000 daltons), and beta-amylase(mol. wt. =200,000 daltons)from Sigma Chemical Co.; ethylenediaminetetraacetate disodium dihydrate (EDTA) from Wako Pure Chemical Industries, Ltd.; DEAE-cellulose (DE52) in pre-swollen grade from Whatman Inc.; Hydroxylapatite (Bio-Gel HTP) from Bio-Rad Laboratories; Sephadex G-100 and G-200 from Pharmacia Fine Chemicals; ammonium sulfate, ammonium peroxodisulfate, bromophenol blue, Coomassie Brilliant Blue R, acrylamide, N, N′ methylene-diacrylamide (Bis), and N, N, N, N-tetramethylene-diamine (Temed) from E. Merck.

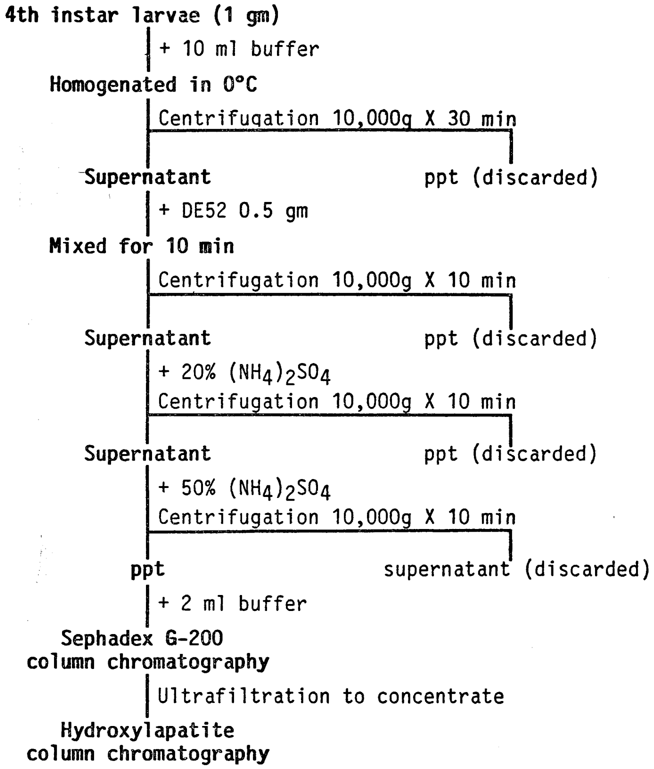
Enzyme assay

For the GSTase activity determination, DCNB was used as the standard substrate, and the spectrophotometric method of Booth et al. (1961) was employed. The change in absorbance at 344nm was converted to μmoles using the extinction coefficient (e= $10nM^{-1}\ cm^{-1}$) for S-(2-chloro-4-nitrophenyl)-glutathione (Askelof et al., 1975).

Purification of GSTase

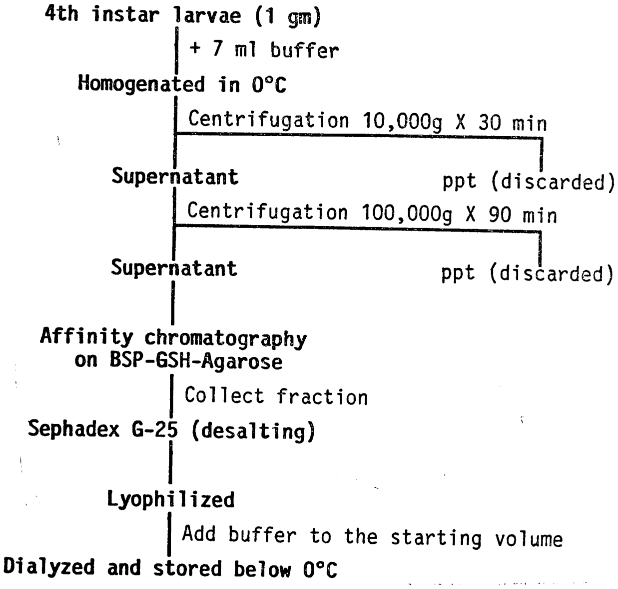
The purification of GSTase from DBM larvae followed two methods: (1) the traditional ammonium sulfate fractionation combined with column chromatography (Scheme 1) described by Motoyama and Dauterman (1977 & 1978) and (2) the newly developed affinity chromatography method (Scheme 2) described by Clark et al. (1977), Simons and Vander Jagt (1977), and Cochrane et al. (1977). Scheme 1 and 2 illustrated the detailed purification steps, and some modifications from previous work in housefly or *Drosophila* spp. were described later in this report. The isolation buffer used for GST-

Scheme 1. Purification of GSTase by traditional method.



ase is 0.01M potassium phosphate(pH 7.4)containing 2mM GSH and 0.1mM EDTA. The specification for Sephadex G-200 column is 2cm (dia.) ×53cm (height), and 1.5 to 1.9ml per tube were fractionated.

Scheme 2. Purification of GSTase by affinity chromatography



The specification is 1.0cm (dia.) ×14.5cm in length for HTP chromatographic column, while the linear gradient from 150ml isolation buffer and 150ml 0.4M potassium phosphate buffer containing the same concentration of GSH and EDTA as the isolation buffer were used to exchange GSTase. The fractions were collected as 5ml per tube.

Molecular weight determination

The GSTase purified from Scheme 1 was loaded in a Sephadex G-100 gel filtration column with the known protein standards and eluted in two buffer systems as they were 0.05M Tris buffer (pH 8.0) and 0.01M phosphate buffer (pH 6.7). The elute was monitored in 280nm for protein peaks. Generally, the methods of Andrews (1964) and Motoyama and Dauterman (1979) were followed.

Electrophoresis

The polyacrylamide gel electrophoresis (PAGE) of Scheme 2 purified GSTase sample in contrast to the crude preparation was performed according to Gordon (1975), Hames and Rickwood(1981). The pH of running gel buffer was 8.9. Protein was stained with Coomassie Brilliant Blue R; GSTase activity was stained with the same enzyme assay solution using DCNB as substrate in 37°C for 30—50min and then scanned at 344nm for absorbance.

Protein determination

Protein was determined by the Lowry method (1951) with Folin-Ciocalteu's phenol reagent, and using BSA as protein standard.

Results and discussions

GSTase purification

Some modifications in the traditional protein purification method (Scheme 1) used in the housefly GSTase study (Motoyama and Dauterman, 1977 & 1978) had been adopted in the very beginning of DBM's GSTase purification. In the housefly preparation,

Table 1. The effect of buffer volume added per gm of *P. xylostella* larvae and 0.5gm DE52 in relation to the initial recovery of GSTase activity in purification.

Buffer volume per gm *P. xylostella* larvae and 0.5gm DE52	Recovered GSTase from 10,000g supernatant
2ml	30-48%
3ml	65%
5ml	86%
10ml	98%

the buffer volume is 200ml for 95gm insects, while the same dilution for the DBM resulted in great GSTase activity loss in the DEAE-cellulose treatment. By raising the buffer: insect ratio to 10 : 1 (V/W), the recovery of GSTase activiey reached 98% (Table 1). Another major change is the omission of glycerol and BSA from the purification buffer since no detectable GSTase activity loss could be found by the above mentioned

omission. The purified GSTase sample without glycerol can be easily lyophilized for storage and adjusted to desirable concentration by redissolving in suitable amount of buffer whenever needed.

Table 2. Purification of GSTase from S-strain *P. xylostella* followed the procedure of scheme 1.

Procedure	Total units* per gm DBM	Yield (%)	Specific activity**	Purification (fold)
1. 10,000g sup.	523.8	100	4.92	1.00
2. DEAE-cellulose	510.7	97	14.46	2.94
3. AS 20—50% ppt	458.5	88	25.97	5.28
4. Sephadex G—200	406.8	78	37.50	7.62
5. Hydroxylapatite	175.7	34	54.50	11.08

* Unit of activity is defined as 1 μmole of DCNB conjugated with GSH per min at 25°C.
**Specific activity is defined as 1 unit of GSTase activity per mg protein.

The GSTase purification followed Scheme 1 is presented in Table 2. As we had reported before that the 4th instar DBM larvae posses high GSTase activity compared to the housefly (Motoyama and Dauterman, 1978). With the exception of the DEAE-cellulose step, the purification of all other steps were not as good as that in the house fly study. Up to the step of hydroxylapatite column chromatography, purification is only 11.08 fold compared to 69 fold in the housefly. The recovery is 34% compared to 55% in housefly. Since no major protein impurity interfered as that in the housfly, the second hydroxylapatite chromatography was not performed.

Table 3. Purification of GSTase from R- and S-strain *P. xylostella* larvae followed scheme 2.

Procedure	(Per gm) R-strain DBM*				(Per gm) S-strain DBM*			
	Total units**	Rec. (%)	Specific activity***	P. F.	Total units**	Rec. (%)	Specific activity.***	P. F.
1. 10,000g sup.	883.1±88.3	100	12.6±0.7	1.0	451.1±42.8	100	8.5±2.5	1.0
2. 100,000g sup.	939.1±74.7	106	17.8±2.2	1.3	412.3±37.4	91	12.1±2.3	1.4
3. Aff. chrom	404.7±29.7	46	435.9±37.5	32.1	253.5±12.3	56	211.3±28.4	24.9

*The 4th instar larvae were used. With 4 and 3 replicateds for R-and S-strain, respectively.
**Unit of activity is defined as 1 μmole of DCNB conjugated with GSH per min. at 25°C.
***Specific activity is defined as 1 unit of GSTase activity per mg protein.
P. F. =Purification factor.

The purification of GSTase by affinity chromatography consists of only three major steps (Scheme 2 and Table 3), and the purification factors were 32.1 and 24.9 in R- and S-strain of DBM, respectively. Nevertheless, the affinity chromatography can be considered as one step purification in the whole scheme, since high speed centrifugation only offered minimum improvement as the purification factors were between 1.3—

Fig. 1. Electrophoresis of affinity chromatography purified GSTase from *P. xylostella* L.
a. sample after 10,000 and 100,000g centrifugation.
b. sample after BSP-GSH-agarose affinity chromatography.

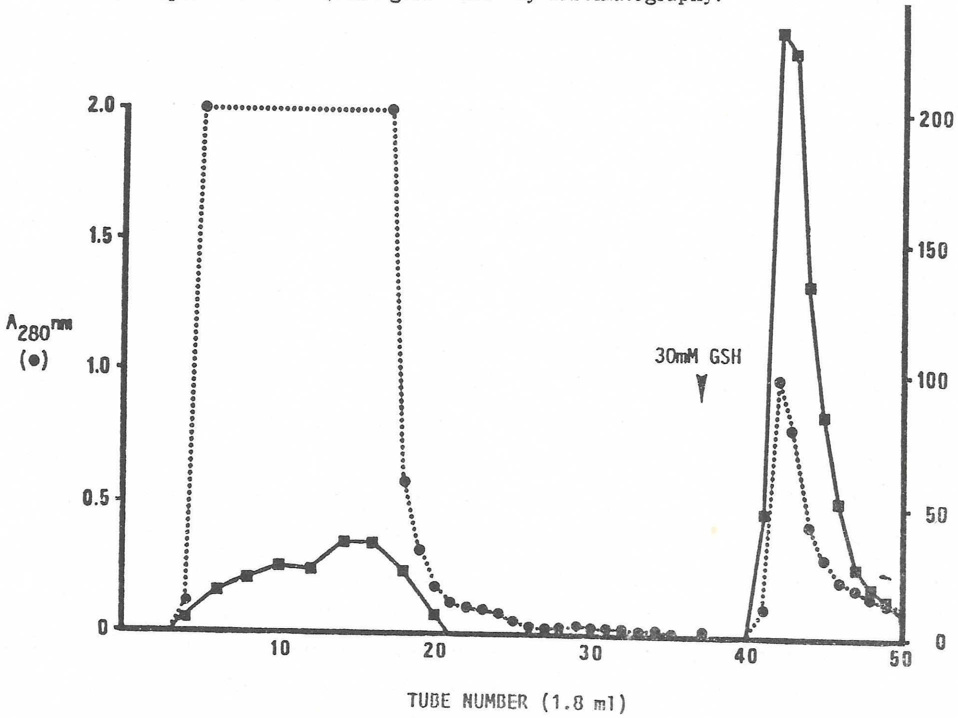


Fig. 2. (a) Profile for the purification of GSTase from S-DBM using BSP-GSH-affinity chromatography.

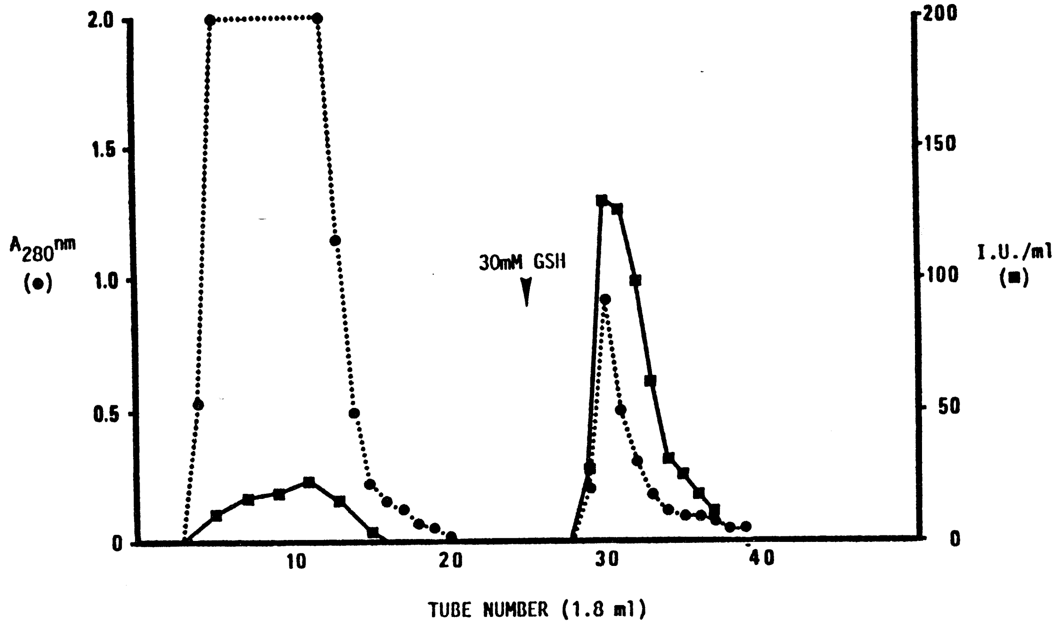


Fig. 2. (b) Profile for the purification of GSTase from R-DBM using BSP-GSH-affinity chromatography.

1.4. The 46—56% yield in GSTase is also better when compared to 34% of the scheme 1 traditional method. Furthermore, the polyacrylamide gel electrophoresis study showed that the affinity chromatography is so specific that only one major protein band could be recognized after staining (Figure 1), which demonstrated the affinity chromatography method is a better choice for GSTase purification in the DBM. Instead of 5mM used in *Drosophila* spp. (Cochrane et al., 1987) and human liver (Simons and Vander Jagt, 1977), 30mM GSH is needed to elute DBM GSTase from the BSP-GSH-agarose column for DBM. The BSP- GSH-agarose affinity chromatography profile for the purification of GSTases from S- and R-strain of DBM were presented in Figure 2a and 2b, and there were 25—27% GSTase activity loss in loading and subsequent buffer washing. Main GSTase activity recovery was obtained right after the introduction of 30mM GSH into the elution buffer. Both profiles were rather similar to that of human liver GSTase reported by Simons and Vander Jagt (1977).

Characterization of the molecular weight of DBM GSTase

The elution character of DBM's GSTase from Sephadex G-200 column in contrast to the protein elution profile is rather similar to the results of housefly (Motoyama and Dauterman, 1978) except the GSTase of DBM can be successfully discriminated from the second major protein peak (Figure 3). In the subsequent hydroxylapatite column chromatography, the sample was eluted without the major protein peak presented (Figure 4). Nevertheless, the needed potassium phosphate concentration to exchange the enzyme was extremely similar to that of housefly's GSTase. The molecular weight of DBM's GSTase measured was between 45,000—46,500 daltons (Figure 5a and 5b) in contrast to 37,000—54,000 daltons (Motoyama and Dauterman, 1978) and 43,000, 44,600 and 53,600 daltons (Motoyama and Dauterman, 1979).

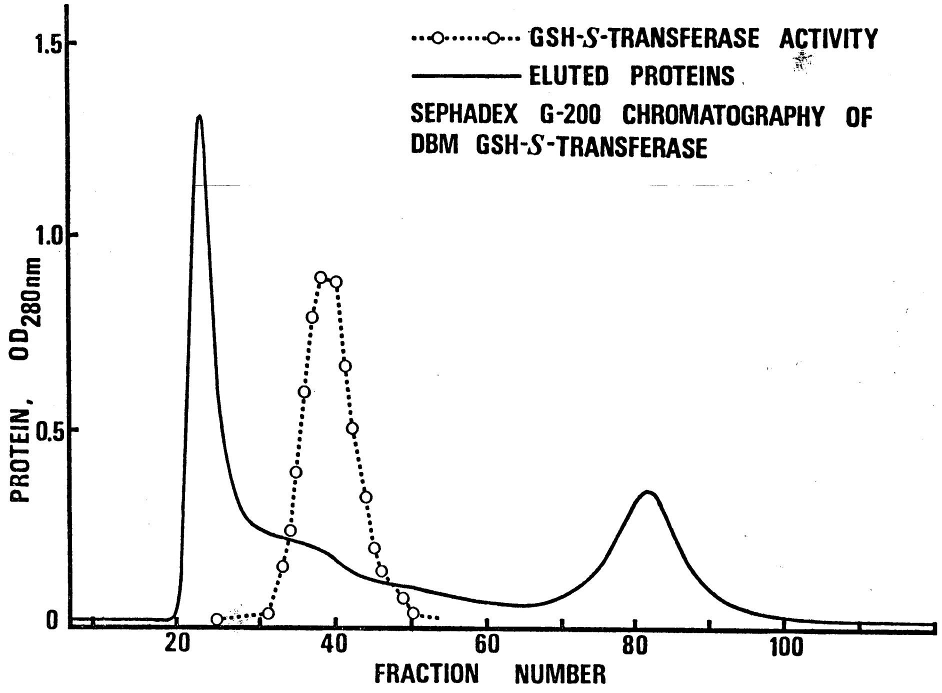


Fig. 3. Sephadex G-200 chromatography of GSTase from S-DBM in purification Scheme 1.

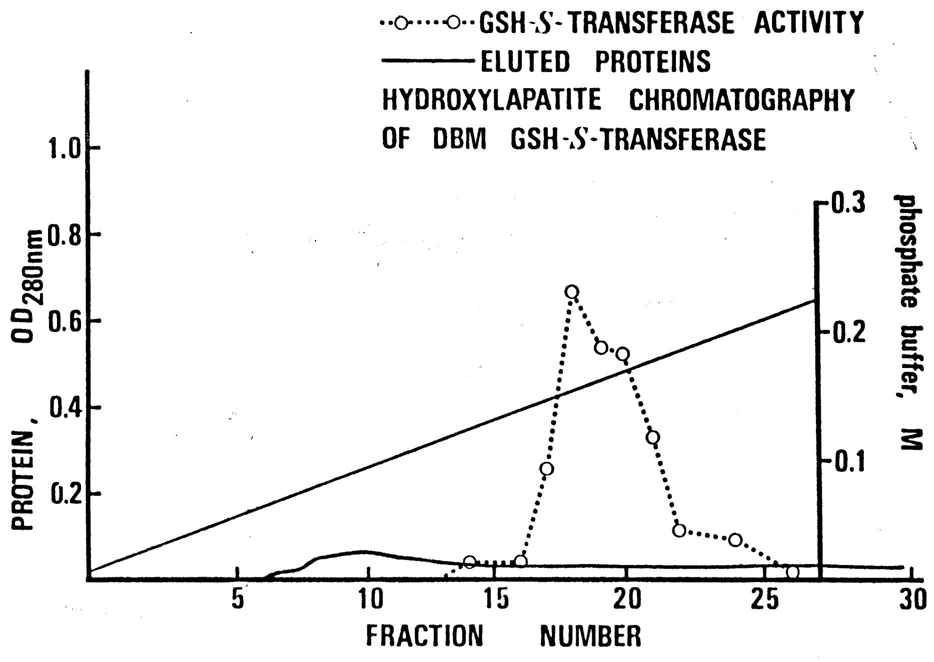


Fig. 4. Hydroxylapatite chromatography of GSTase from S-DBM in purification Scheme 2.

Electrophoresis and staining of GSTase

DBM's GSTase sample obtained from Scheme 1 procedure still contained many protein impurities in polyacrylamide gel electrophoresis, hence only the sample purified from the affinity chromatography was investigated further (Figure 1). The crude GSTase preparation served as the comparative check. The staining method for GSTase activity described by Clark(1982)had been tested but no satisfactory result could be obtained, hence a different GSTase activity staining method was developed. After electrophoresis, the gel was rinsed in 0.1M Tris buffer (pH 9.0) and then soaked in 50ml of 0.1M Tris buffer (pH 9.0) containing 1mM DCNB and 5mM GSH in 37°C for 50 minutes. After incubation, the gel was transferred into a densitometer and scanned at 344nm for absorbance reading. A strong single absorbance peak was located at Rf=0.06 to 0.21 (Figure 6) while the protein stain of the same gel revealed the single protein band located at Rf=0.06—0.11 (Figure 1). The reason for the GSTase activity peak and the protein location were close but not exactly matched is not clear and needs to be investigated further. However, the PAGE result definitely demonstrates that affinity chromatography has superior GSTase purification capability when compared to the traditional method.

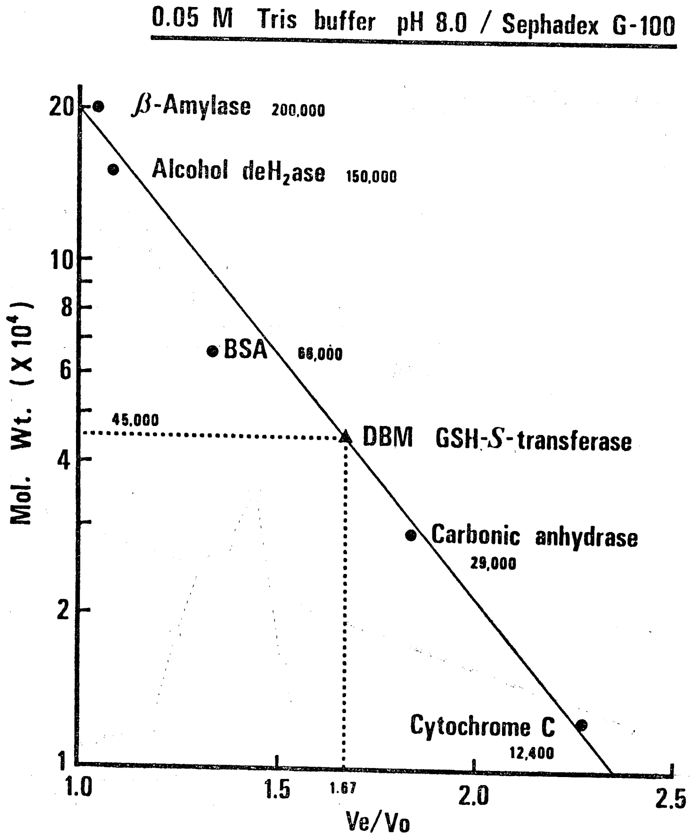


Fig. 5. (a) Molecular weight determination of GSTase in Sephadex G-100 gel filtration column with 0.05M Tris buffer (pH=8.0). Enzyme source: S-DBM inpurification Scheme 1.

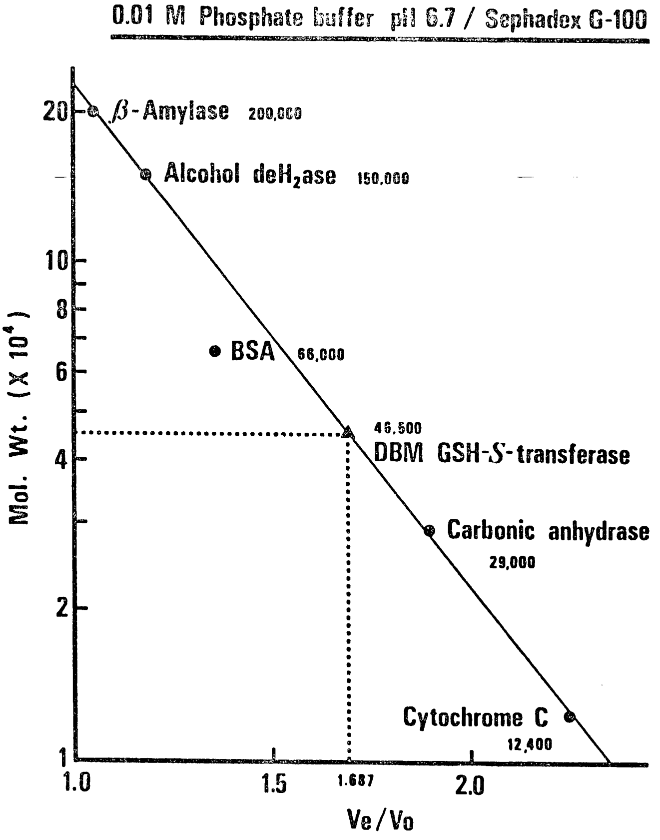


Fig. 5. (b) Molecular weight determination of GSTase in Sephadex G-100 gel filtration column with 0.01 M phosphate buffer(pH6.7). Enzyme source: S-DBM inpurification Scheme 1.

GSTase in relation to insecticide resistance in the DBM

In previous report, the organophosphate-resistant DBM possessed higher GSTase activity compared to both the susceptible and pyrethroid-resistant DBMs, and the difference in enzyme activity was approximately 2 to 4 fold (Cheng et al., 1983). In this investigation, the field collected multiple resistant DBM also possessed 2 fold GSTase activity in contrast to the susceptible DBM. The experiment had been repeated 3 to 4 times, and similar difference appeared every time. The higher GSTase activity in the resistant DBM was attributed from both enzyme protein and the specific activity (Table 3). Although direct evidence to relate GSTase to the organophosphate resistance in the DBM is still lacking, the consistant appearance of high GSTase activity in the resistant DBM strongly suggested the possibility of GSTase being an organophosphate metabolic enzyme, and may contribute to the resistance.

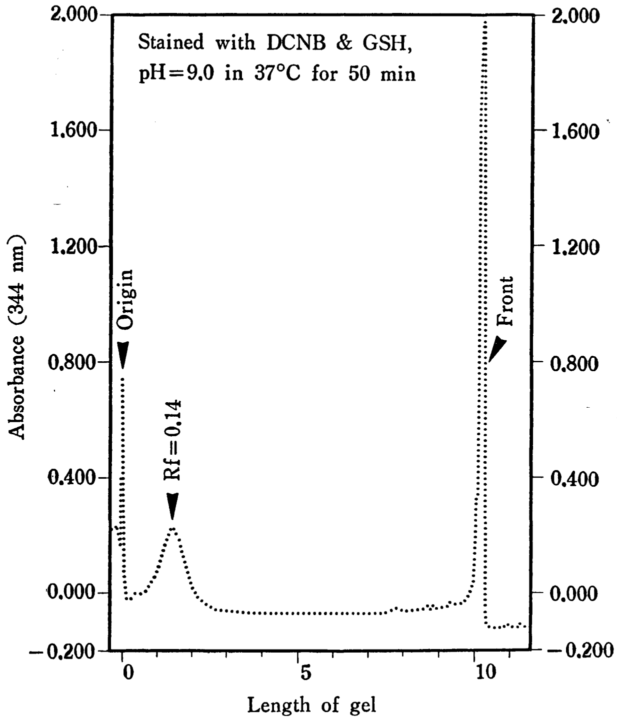


Fig. 6. Densitometer scan of GSTase activity in electrophoresis gel. (substrate: DCNB, incubation temperature:37°C, scanning absorbance:344nm.)

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小菜蛾Glutathione-S-轉移酶之純化與定性[1]

鄭 允 林端方 邱紀松 高靜華[2]

摘 要

Glutathione-S-轉移酶在小菜蛾以及其他昆蟲體內，被認爲可能與抗藥性有關，尤其是有機磷殺蟲劑中之甲基或乙基的解裂，而使殺蟲劑在到達毒理作用點以前因分解而失效。小菜蛾之抗藥性極困擾蔬菜之蟲害防治，而有關有機磷抗性之機制，迄今仍不完全瞭解，故就此蟲之 Glutathione-S-轉移酶進行純化與定性。本研究以兩種方式進行該酶之純化，一爲傳統之「鹽析」及「分子篩分離」以及「離子交換」方法，一爲利用新發展之「親和性分析柱」方式，結果發現後者之純化步驟簡單，回收率及酶之純度均較傳統之純化方法爲佳，純化倍數爲 25—32倍之間，同時測得小菜蛾之 Glutathione-S-轉移酶分子量介於 45,000～46,500 daltons 之間，而且，此酶之活性在抗性品系小菜蛾高過感性品系 2 倍以上。

1.臺灣省農業試驗所研究報告第1433號，本計畫承國科會補助（編號NSC—76—0409—B055—08及NSC—77—0409—B055—08）。
2.本所應用動物系研究員、計畫助理、助理、助理。臺灣省 臺中縣 霧峰鄉。

中華農業研究 (Jour. Agric. Res. China) 37(4) : 453~457 (1988)

A newly invaded insect pest *Liriomyza trifolii* (Diptera: Agromyzidae) in Taiwan[1]

C. L. Wang and F. C. Lin[2]

Abstract: *Liriomyza trifolii* (Burgess) was first found in Taiwan in Feb. 1988. High leafminer populations and serious leaf damage were observed in gerbera fields. Characteristics of this species was described, an comparison of the species with *L. bryoniae* and a key to the species of *Liriomyza* of Taiwan were made.

There were eight species of genus *Liriomyza* recorded from Taiwan: *L. brassicae* (Riley), *L. cepae* (Hering), *L. compositella* Spencer, *L. subpusilla* (Malloch), *L. yaosumatsui* Sasakawa (Sasakawa, 1972), *L. chinensis* (Kato), *L. viticola* (Sasakawa) (Sasakawa & Fan, 1985) and *L. bryoniae* (Kaltenbach) (H. S. Lee, 1988, personal communication). Among these species, *L. bryoniae* was the most common and wide spread one. Usually it causes leave damage on melons, mustards, garden peas, gypsophila and many other horticultural crops. Our previous survey showed that *L. bryoniae* was the only leafminer on gerbera. It was found in low populations and the damage was neglectable.

In Feburary 1988, a distinct type of leafminer was found by authors on gerbera (*Gerbera jamesonii* Bolus.) at Da-Kan of Taichung area. Leaves of gerbera in this field were seriously damaged (Fig. 1). This leafminer could not be efficiently controlled by farmers' weekly sprays of highly toxic insecticides such as furadan, tamaron, azodrin, dimethoate, and all kinds of pyrethroids. It is evident that this species is not the same

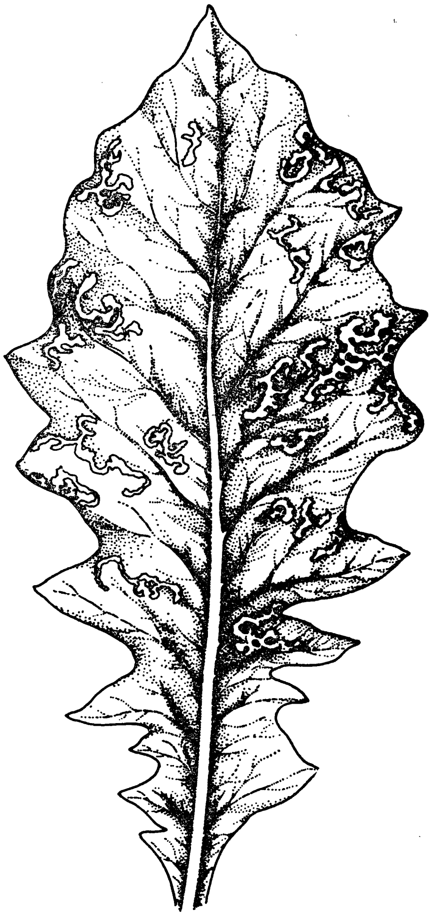

Figure 1. Leaf of gerbera damaged by *Liriomyza trifolii*.

1. Contribution No. 1439 from the Taiwan Agricultural Research Institute.

2. Associate Entomologist and Research Assistant, Department of Applied Zoology, Wufeng, Taichung Hsien, Taiwan 41301, ROC.

with *L. bryoniae*.

A comparison of the morphological characteristics of this species with *L. bryoniae* was made and results showed that they are quite different. (Table 1).

Specimen of this leafminer were sent to Mr. M. van de Vrie at Floriculture Research Station in the Netherlands and Dr. M. Sasakawa at Kyoto University in Japan for ide-

Table 1. Comparison of *Liriomyza trifolii* with *L. bryoniae*

Growth Stage	Characteristics	
	L. bryoniae	*L. trifolii*
Larva:	1. body yellow anteriorly and white posteriously.	1. same color in the body.
	2. a flat area between the 1st and the 2nd teeth (Fig. 2a).	2. the 1st and the 2nd teeth closely connected (Fig. 3a).
	3. seven to twelve pores on spiracle (Fig. 2b)	3. three pores on spiracle (Fig. 3b).
Pupa:	gold-yellow or darkbrown black.	yellowish brown.
Adult:	1. length of M_{1+2} vein of discal cell about three times of m-m vein (Fig. 2c).	1. length of M_{1+2} vein of discal cell about twice of m-m vein (Fig. 3c).
	2. yellow strips on abdomen tergites with even margins (Fig. 2d).	2. yellow strips on abdomen with central point protruding ahead (Fig. 3d).

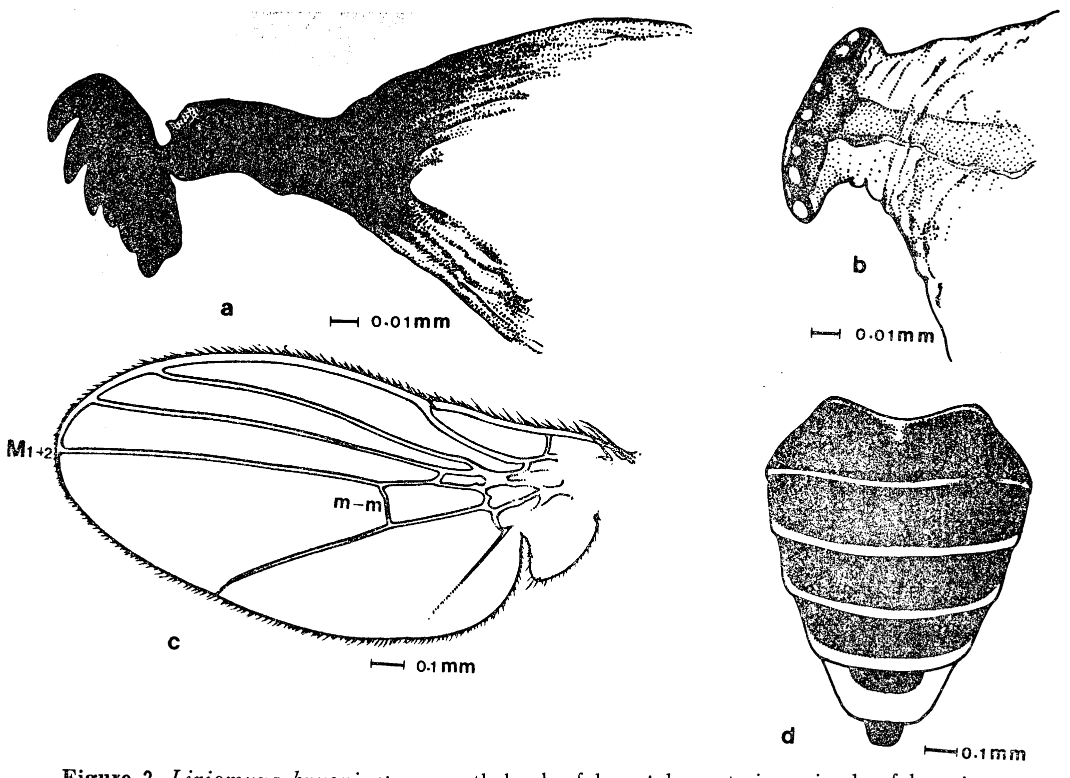

Figure 2. *Liriomyza bryoniae*: a, mouth hook of larva; b, posterior spiracle of larva; c, wing; d, dorsal view of abdomen.

ntification. They both confirmed the authors suspect that it was *L. trifolii* (Burgess).

A provincial survey (under the sponsor of the Provincial Department of Agriculture and Forestry) on the occurrence of *L. trifolii* on gerbera, chrysanthemum, leguminous and cucurbitaceous crops was conducted in June, 1988. Our preliminary results showed that this leafminer occurred only in central Taiwan at several gerbera fields. It is likely that *L. trifolii* is invaded into Taiwan along with the import of gerbera seedlings from the Netherlands or other countries.

L. trifolii is an important pest on ornamental and vegetable crops, and has been reported in at least 40 countries(Minkenberg, 1988). Very large populations were frequently present and heavy infestations usually cause destroying of leaves which may cause reductions in crop value or yield (Spencer, 1973). Its distribution has expanded rapidly in the past ten years than ever. The frequent trading of plant products and seedlings among various areas and the development of insecticide-resistance of *L. trifolii* are usually considered the reasons of its rapid spread (Minkenberg & Lentern, 1986).

The taxonomic characteristics of *L. trifolii* was described as following:

Oscinis trifolii Burgess, 1880. Rep. U. S. Agr. 1879 : 200-201.

Liriomyz trifolii de Meijere, 1925. Tijdschr. Ent. 68 : 195-293.

Liriomyza alliovora Frick, 1955. J. Kansas Ent. Soc. 28(3) : 88-92.

Adult: Orbits entirely yellow, both vertical bristles on yellow ground; all antennal

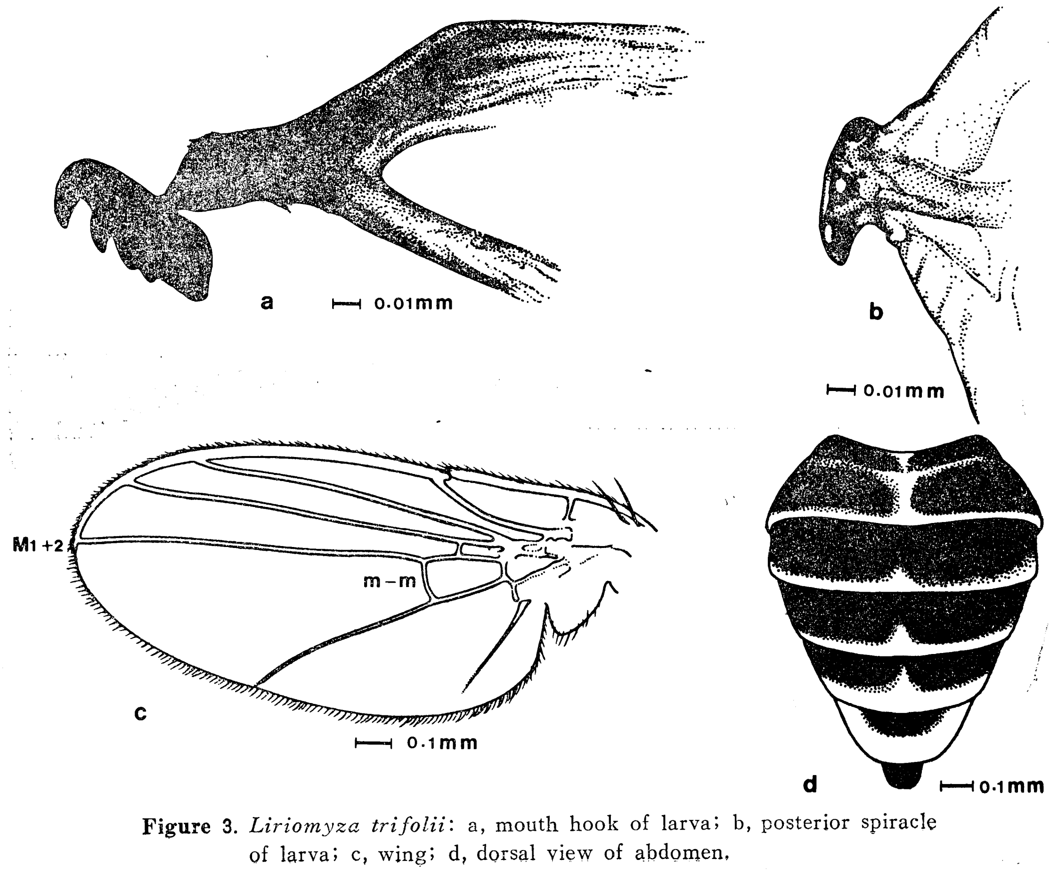

Figure 3. *Liriomyza trifolii*: a, mouth hook of larva; b, posterior spiracle of larva; c, wing; d, dorsal view of abdomen.

segments bright yellow, third with inconspicuous pubescence; mesonotum blackish gray, distinctly mat, acrostichals in three or four rows in front, reduced to two rows behind, yellow patch at each hind corner adjoining scutellum; mesopleura with black patch extending along lower margin; abdomen with tergites variably yellow laterally and on hind margins. legs: coxae yellow, femora largely so but with slight, variable brownish striation; tibiae and tarsi darker, brown, wing length from 1.25mm in male to 1.9mm in female, discal cell small, last section of vein M_{3+4} three times length of penultimate. Early stages: Egg oval, ca. 0.2×0.1mm, originally transparent and later turns creamy. Larva initially colorless, darkens to yellow as it matures. Three instars. Posterior spiracles each with three pores, the outer two elongate; mouth hook with four teeth, the first one more seperated from the others. Puparium yellowish-brown.

In order to identify the various leafminers of *Liriomyza*, a key was made:

Key to species of *Liriomyza* of Taiwan

1. Mesonotum with yellow semicircular area adjoining scutellum······*subpusilla* (Malloch)
   Mesonotum without such yellow prescutellar area··························2
2. Scutellum entirely black··························3
   Scutellum largely yellow··························5
3. Third antennal segment rounded··························*viticola* (Sasakawa)
   Third antennal segment with pointed angle dorsoapically··························4
4. Coxa black, femora largely black on upperside, more yellow below······*cepae* (Hering)
   Coxa and femora bright yellow··························*chinensis* (Kato)
5. Parafrontalia normally brownish to black··························*brassicae* (Riley)
   Parafrontalia entirely yellow··························6
6. Inner vertical bristle growing on yellow area but the outer on black··························*compositella* Spencer
   Head with both vertical bristles arising from yellow area··························7
7. Mesonotum conspicuously mat grey··························*trifolii* (Burgess)
   Mesonotum shining black··························8
8. Ultimate section of M_{3+4} about twice length of the penultimate ··························*bryoniae* (Kaltenbach)
   Ultimate section of M_{3+4} about three and half times as long as the penultimate··························*yasumatsui* Sasakawa

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新侵入臺灣之非洲菊斑潛蠅 *Liriomyza trifolii*[1] (雙翅目：潛蠅科)

王清玲　林鳳琪[2]

摘　要

臺灣原已有8種斑潛蠅（*Liriomyza*）之記錄，民國77年2月又於臺中市北屯區大坑附近之非洲菊園中首次發現非洲菊斑潛蠅（*Liriomyza trifolii* (Burgess)），其於發生園中族羣密度極高，葉片被害嚴重。本種潛蠅爲花卉、蔬菜之重要害蟲，分布於世界四十餘國，由於其本身高度抗藥性之產生，以及植物種苗之國際交易頻繁，其於最近十年間之世界性擴散尤其迅速。本種潛蠅在臺灣最初之分布均在非洲菊上，故有可能是藉由國外進口之非洲菊苗而侵入。本文除描述其分類特徵外，並與在臺灣多種園藝作物上普遍發生之 *L. bryoniae* (Kaltenbach) 做一外形鑑識上之比較，此外亦製做一分辨臺灣所有9種斑潛蠅之檢索表。

1.臺灣省農業試驗所　研究報告第 1439 號。

2.本所應用動物系副研究員、助理。臺灣省　臺中縣　霧峰鄉。

中華農業研究 (Jour. Agric. Res. China) 37(4) : 458~469 (1988)

Working Patterns, Capacity, and Cost of Rice Combine[1]

Chia-chung Chen[2]

Abstract: A series of working locus equations are established to study the effect of the working patterns on efficiency and capacity of rice combine. As the field area was less than 0. 4ha, circuitous method was better. At the range of 0. 4—0. 5ha, either pattern could be adopted. Continuous pattern was good for larger area.

Operating capacity and the machinery price are the major deteriming factors for working cost. Large combines will be more economical for long-term development.

INTRODUCTION

Harvesting is the most important farm working for rice production. In 1986, about 90% of the rice paddies were harvested by machinery. Because of the prevalence of the "custom work" system prevails the machinery-owner works for himself and neighbour s. The typically work hours per year for rice combines was so high that the depreciati on period was reduced. In order to improve the working capacitie and reduce the oper ating cost, it is necessary to study the relations of the working patterns and efficiency of rice combine. The operating cost also need to be studied.

Different working patterns for big farm eruipment in USA were described by Hunt (1979). Many researches of farm machinery cost had been presented (Hassan et al., 1978; Renoll, 1981). The study of working patterns of harvest machinery in Japan only included two-row riding type combines (Shimizu and Fukayaama, 1971).

In this study of working capacity, the working patterns were formulated as a series of locus equations. The related parameters were investigated and substituted into these equations to find the working efficiency of three types of combines. The cost of rice combine are divided into fixed and variable cost. Five types of machinery were studied and compared.

MODEL DEVELOPMENT

I. Working patterns and capacity

1. Contribution No. 1440 from the Taiwan Agricultural Research Institute, Taiwan, Republic of China. This paper was partially revised and condensed from the papar that presented at the 1988 Intern ational summer meeting of the ASAE. (ASAE paper No. 88—5009) .

2. Associate Researcher, Department of Agricultural Machinery, Taiwan Agricultural Research Institute, Wu-feng, Taichung, Taiwan, 41301, ROC.

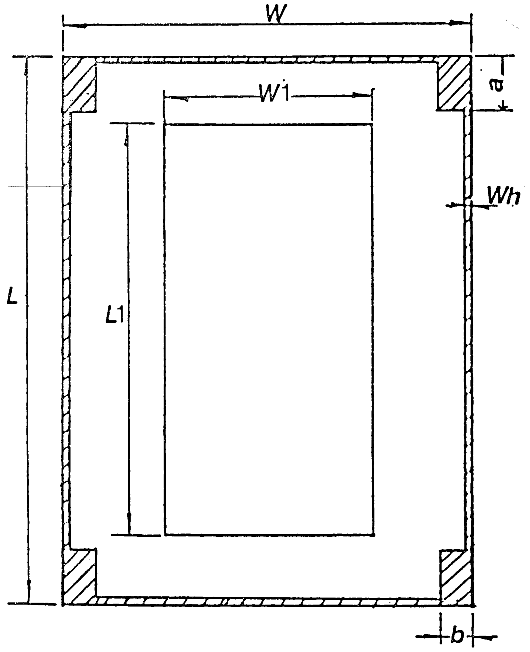

Fig. 1. The standard shape of paddy field and headland

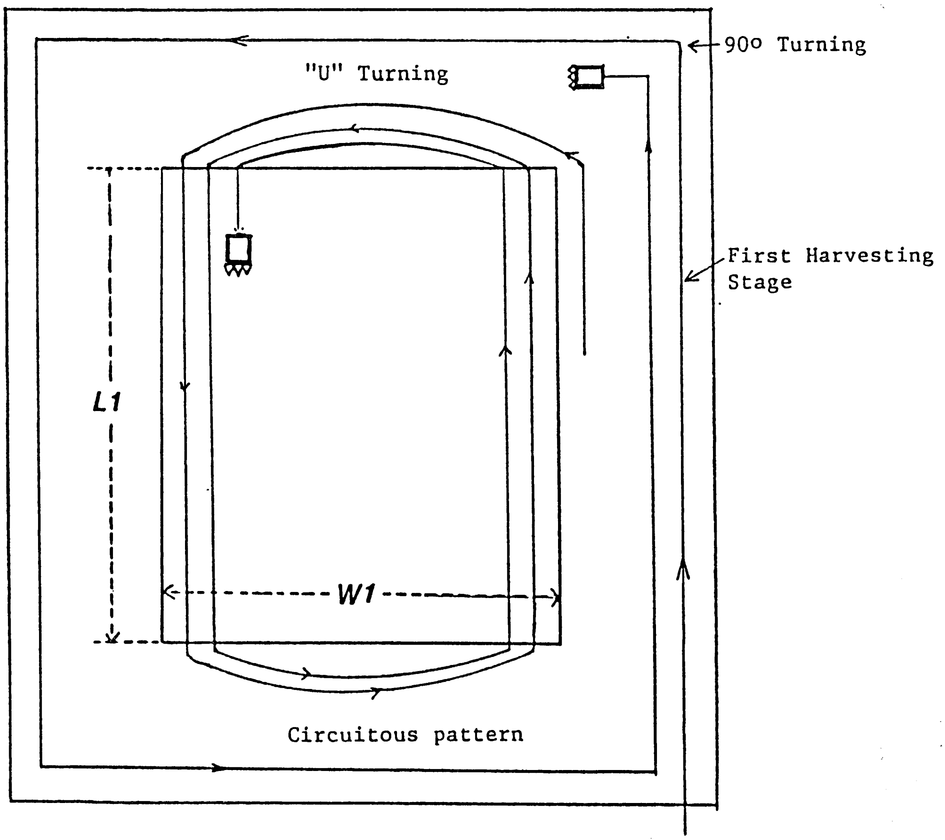

Fig. 2. The first harvesting stage and circuitous pattern

To effectively utilize the paddy field, no unprocessed land was left for headland. Before using combines, the fields needed to be reaped by hand at four corners and around four sides to provide enough turn strips for machinery (showed in Fig. 1). All reaped grains were threshed by the thresher of combine.

A. Working methods

The first harvest stage was worked around the field side to obtain enough headland for next operating work (Fig. 2). Each corner took a time to turn a 90° corner. The second stage were divided into two different patterns.

a. Circuitous pattern

As the residual field width (W1) was below 20 meters, the combine kept on oper ating that circulating around the working area as shown in Fig. 2. The field length for harvesting was fixed at L1.

If W1 was greater than 20 meters, the residual working field was divided into sev eral subregions that width are within the range of 10—12 meters. The subregions were operated by inner-circular or outer-circular patterns (Fig. 3). As the combine finished one long side working, it turned along a "U" type path to next start point.

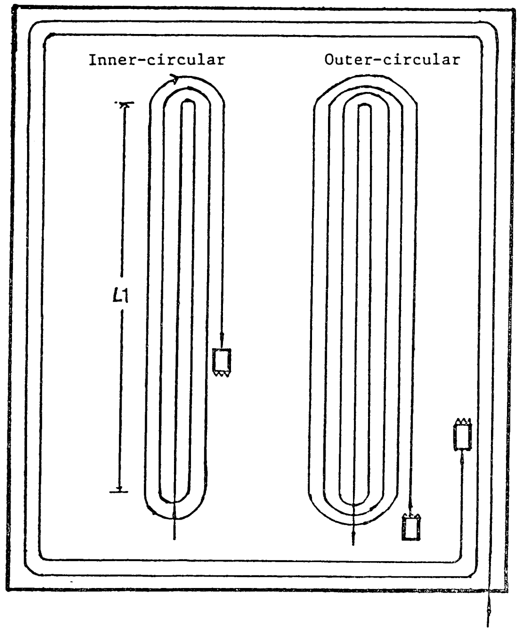

Fig. 3. Two types of circuitous pattern

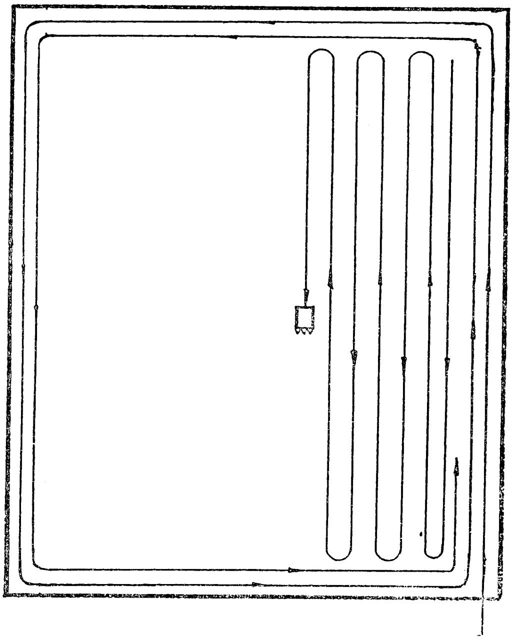

Fig. 4. The continuous pattern

b. Continuous pattern

This pattern is shown in Fig. 4. After the first stage work, combine harvested rice by continuous pattern. Each time required the 180° turninng at a limit distance.

B. The analysis of required time

a. Headland area and operation time

The headland area, AH (m^2), could be calculated as following :

$$AH = 4ab + 2Wh^{*}(L + W - 2a - 2b) \quad \cdots\cdots (1)$$

Where a = length of headland (m)

b = width of headland (m)

Wh = width of the manual reaped around four sides (m)

W = width of paddy field (m)

L = Length of paddy field (m)

The manual reaped time for headland was TH (sec),

$TH = AH*Cm$ ······························ (2)

Where Cm = manual capacity of reaping by hand (sec/m^2)

The required time to thresh the grains was TS (sec),

$TS = AH*Sm$ ······························ (3)

Where Sm = operating capacity for thresher to thresh the grains that reaped by hand (sed/m^2)

b. The operating time for the first stage.

The travelling paths of the rice combine at the first stage are listed as Table 1. The total travelling pathes was Pt (m),

Table 1. The travelling pathes of rice combine at the first stage

No. of Circular	Long side	Short side
1	2L—w	2W—3w
2	2L—5w	2W—7w
3	2L—9w	2W—11w
4	2L—13w	2W—15w
——	——	——
n	2L—(4n—3)w	2W—(4n—1)w
Total	2nL—(2n*n—n)w	2nW—(2n*n+n)w

$Pt = 2*N1*(L+W) - 4*w*N1^2$ ······························ (4)

Where N1 = require circular number for the first stage

w = effective operating width (m)

The required operating time for this stage was T1 (sec),

$$T1 = \frac{2*N1*(L+W) - 4*N1*N1*w}{S} + 4*N1*Tf \quad \cdots\cdots \quad (5)$$

Where S = the operating velocity for combine (m/sec)

Tf = the time to turn a 90° corner (sec)

c. The working time for circuitous pattern

As W1 is less than 20m, the required times for rotation N2,

$N2 = W1/w$ ······························ (6)

The required operating time for this stage was T2 (sec).

$$T2 = \frac{L1}{S} \times N2 + \Sigma Tui \quad \cdots\cdots \quad (7)$$

Where Tui = require turning time for "U" type rotation (sec),

If W1 is greater than 20m, some subregions of equal width (Ws1) and the smallest subregion (width was Ws2) composed of the residuca field.

$$W1 = K \times Ws1 + Ws2 \cdots\cdots (8)$$

Where K = the number subregions in which had same width, Therefore,

$$N3 = K \times \frac{Ws1}{w} + \frac{Ws2}{w} = K \times i + j \cdots\cdots (9)$$

The requierd time for this stage was T3 (sec),

$$T3 = \frac{L1}{S} \times N3 + K \times \sum^{i} Tui + \sum^{j} Tu2 \cdots\cdots (10)$$

d. The working time for continuous

In this pattern, the total required rotation times could be expressed as,

$$N4 = W1/w \cdots\cdots (11)$$

The total operating time for this stage was T4 (sec),

$$T4 = \left(\frac{L1}{S} + Tr\right) \times N4 \cdots\cdots (12)$$

Where Tr = the time for turning of 180° (sec)

C. The operating efficiency and operating capacity

The total working time for whole field operation was T1.

a. Circuitous pattern, W1 < 20m

$$Ta = TH + TS + T1 + T2 \cdots\cdots (13)$$

b. Circuitous pattern, W1 > 20m

$$Tb = TH + TS + T1 + T3 \cdots\cdots (14)$$

c. Continuous pattern,

$$Tc = TH + TS + T1 + T4 \cdots\cdots (15)$$

The theoretical total working time is Te (sec),

$$Te = \frac{Area}{S \times w} = \frac{L \times W}{S \times w} \cdots\cdots (16)$$

The operating efficiency was e,

$$e = \frac{Te}{Ti} \cdots\cdots (17)$$

The field operating capacity was C (ha/hr),

$$C = 0.36 \times e \times S \times w \cdots\cdots (18)$$

II. Cost analysis

In this study, Operating cost were divided into fixed and variable cost

A. Fixed cost

Fixed costs included the depreciation and interest on investment. Tax, insurance, and shelter costs were not considered for rice combine.

a. Depreciation

The straight-line method was adopted to estimate the depreciation costs. The annual depreciation charge was D (NT$/yr),

$D=(Pc-Ps)/N$ .... (19)

Where Pc = purchase price (NT$)

PS = salvage value (NT$)

N = estimated economic years of life (yr)

b. Interest

The interest cost for per years is I (NT$/yr),

$$I=\left(\frac{Pc+Ps}{2}\right)\times i \quad (20)$$

Where i = the annual interest rate and was 8.5% in Taiwan.

B. Variable costs

Variable costs included repairs, fuel and lubricant consumption, and labor.

a. Repairs cost

Owing to the rapidly renew periods for rice combine, the concept of accumulated repair cost was not suitable. A simple method to estimate the repair cost was to adopt the idea of total repair coefficient (Cr). Cr was the ratio of the total repair cost from purchased to worn-out to the purchase price.

The repairs cost per year can be calculated as R (NT$/yr),

$R=Pc\times Cr/N$ .... (21)

b. Fuel and lubricant cost

The fuel consumption coefficient, K, was expressed as :

K = 2.7 NT$/hp−hr .... (22)

The estimated cost of fuel was F (NT$/yr),

$F=K\times Hp\times H$ .... (23)

Where Hp = the horsepower of combine (hp)

H = the annual working hourse (hr/yr)

The lubrication consumption cost was assumed to be as a portion of the oil cost. The lubricant oils costs was O,

$O=r\times F$ .... (24)

Where r = the average ratio value for oil cost

c. Labors cost

The annual labors cost were determined as L (NT$/yr),

$L=Lc\times H\times PM$ .... (25)

Where Lc = the hourly wage (NT$/hr)

H = annual operating hours (hr/yr)

PM = the required labors, two persons for combine

C. Annual operating cost

The annual operating cost (Ct) was,

$$Ct=D+I+R+F+O+L$$

$$=\frac{0.9\times Pc}{N}+0.04675\times Pc+\frac{Cr\times Pc}{N}+(1+r)\times K\times Hp\times H+Lc\times H\times PM \quad (26)$$

The operating capacity, Fc (ha/hr), was,

$$Fc = Ta/H \cdots\cdots (27)$$

Where Ta = the total annual working areas (ha)

H = the total annual operating hours (hr)

The total economic working years was N (yr),

$$N = \frac{Th}{H} = \frac{Th \times Fc}{Ta} \cdots\cdots (28)$$

Where Th = the total economic working hours (hr)

Let Ca was the annual operating cost per hectare, combined Eq. 26, 27, and 28.

$$Ca = \frac{Ct}{Ta} = \frac{(Pc-Ps)}{Fc \times Th} + 0.04675 \times \frac{Pc}{Ta} + \frac{Pc \times Cr}{Fc \times Th} + \frac{(1+r) \times K \times Hp}{Fc} + \frac{Lc \times PM}{Fc} \cdots\cdots (29)$$

MODEL PARAMETERS

A. Working patterns and capacity

The parameters of working capacity for rice combine were collected in time studies of rice harvesting. The observers recorded the following data for three types of comb ines :

Turning time, Tr, Ta, and Tf

Unloading time

Reaped area and required time by hands

Grains threshed time

Total harvesting time

These data were used to calculate the effective field efficiency. The average value are listed in Table 2.

Table 2. The parameters of operating capacity of rice combines

Item	YS—1300	TC—1800	MC—2450
w (m)	0.75	1.05	1.45
S (m/sec)	0.67	0.79	0.85
a (m)	2.0	5.0	5.0
b (m)	2.0	4.0	4.0
Wh (m)	0.3	0.3	0.0
Tf (sec)	12.6	13.4	12.3
Tr (sec)	15.0	12.0	11.0
Sm (sec/m*m)	6.4	5.2	4.85
Cm (sec/m*m)	84.0	84.0	84.0
Nl	8.0	6.0	5.0

B. Operating cost

The specifiations for operating costs of combine were collected througn personal interviews of custom operators and field investigation.

Information gathered by the interviewers included :

Annual working area and hourly use

Custom rate and operater's wage

Fuel and lubricant oil requirements

Spare parts and repair costs

Purchase and salvage price

Operating capacity

The information of five types of combines are listed in Table 3.

Table 3. The parameters of operating costs of rice combine

Item	YS—1300	MC—1700	TC—2200	MC—2250	TC—3500
Hp (hp)	13	15	21	24	32
w (m)	0.75	1.02	1.30	1.35	1.35
C (ha/hr)	0.126	0.162	0.188	0.237	0.342
Nc (N.T.$)	265,000	390,000	580,000	670,000	970,000

RESULTS AND DISCUSSIONS

A. Operating patterns and capacity

From the investigative results, Tu value was found to be a function of turning distance.

The total time for "U" turning was ΣTui. For threr types of combine, ΣTui were found to be the function of width of subregions (Ws),

1. YS−1300

$$\Sigma Tui = 24.6 + 34.4 \times Ws + 5.56 \times Ws \times Ws \cdots\cdots (30)$$

2. TC−1800

$$\Sigma Tui = 39.0 + 25.9 \times Ws + 2.44 \times Ws \times Ws \cdots\cdots (31)$$

3. MC−2450

$$\Sigma Tui = 9.84 + 33.4 \times Ws + 2.01 \times Ws \times Ws \cdots\cdots (32)$$

Combining all information, the working efficiency of three types of combine for two methods are shown in Fig. 5.

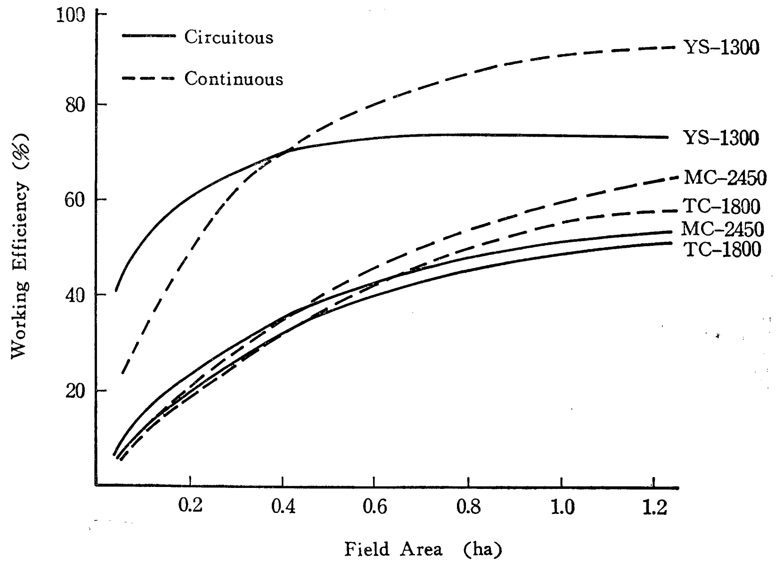

Fig. 5. The working efficiency vs field area

YS-1300, the smallest type, had the largest working efficiency. The reasons could be explained that small machinery required small area of headland and was more easy for turning. As the field area below 0.4 ha, the working efficiency of circultous patterns was higher than those of continuous patterns and the results was contrary to larger area.

MC-2450 had the similar areas of headland with TC-1800. The turning time for Tf, Tu, and Tr were also similar. Owing to faster operating speed and wider operating width, it had the higher efficiency.

The operating capacity for these combines are shown in Fig. 6. The smallest com bine, YS-1300, although had the highest efficiency, revealed the lowest capacity due to its low operating speed and narrow operating width. Above the 0.5ha, it apporached the limitation of 0.12ha/hr. In spite of the same working efficiency, MC-2400 showed a significant improvement on working capacity.

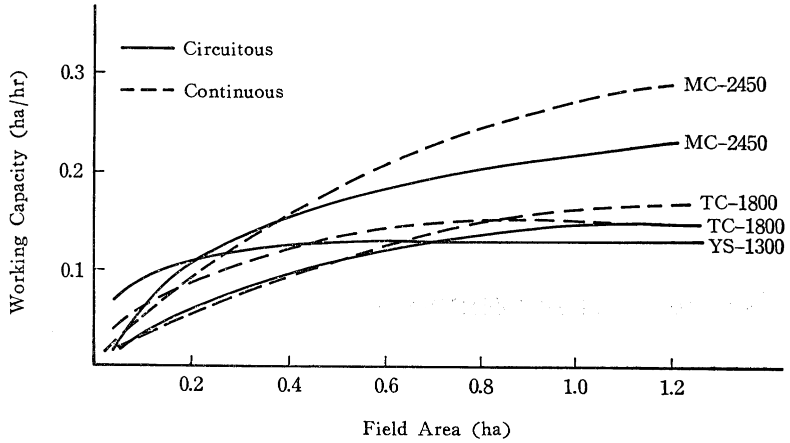

Fig. 6. The working capacity vs field area

Field area showed the similar effect on the working capacity for three types of co mbines. As the area was below 0.4ha, circultous patterns was the better method. At 0.4—0.5 ha, either patterns could be adopted. For larger area above 0.5 ha, continuous pattern was worth recommending.

B. Operating cost

From the investigative results, Ps=0.1Pc, Th=1500hr, Cr=0.5, r=0.3, Lc=70 NT$ /hr. By Eq. 29, Ca became,

$$Ca=9.333E-4\times\frac{Pc}{Fc}+4.675\,E-2\times\frac{Pc}{Ta}+3.51\times\frac{Hp}{Fc}+\frac{140}{Fc}\cdots\cdots\cdots\cdots\quad(33)$$

Hp was found to have a highly linear relation with Pc, so the purchase price and operating capacity were the major effective factors for operating cost per hectare per year.

The operating costs for five rice combines with different annual working areas are shown in Fig. 7. All costs decreased as total working areas increased. The smallest combine, YS-1300, had the lowest cost which reflected their simple design and lower

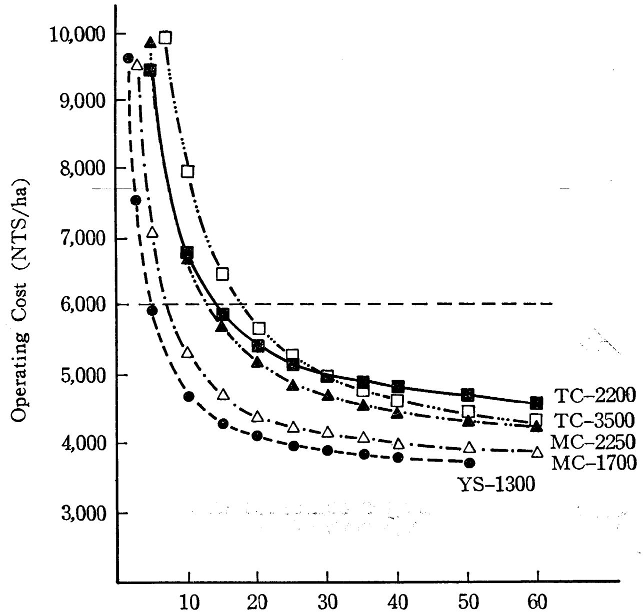

Fig. 7. The operating costs for five Rice Combines

purchase price. A special case was TS-3500. As total working areas increased, its ope rating cost significant decreased. It indicated its potential to work for more areas.

The average custom rate was 6000 NT $ /ha. As the operating area was above 20ha, the benefit became positive for all types of combines.

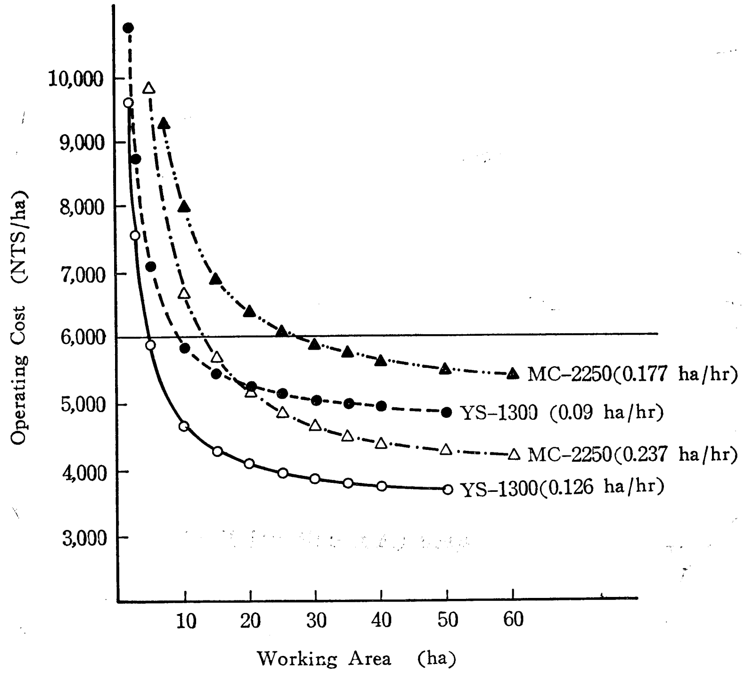

Fig. 8. The effect of field capacity on operating cost

The effect of the operating capacity on cost could be estimated by Eq. 33. The comparison of the costs for combines with different capacity are shown in Fig. 6. As the capacity reduced 30%, the increase cost was 1168NT$/ha for YS-1300, and 1218 NT$/ha for MC-2250. No benefit could be obtained as the annual working area below 30ha for MC-2250. This result indicated the significant effect of capacity on operating cost.

Smallest combine had the lowest cost. However, the weather and crop condition seriously restricted the available working days of combines for each harvesting seasons. The required working day of three combines for two annual working areas are listed in Table 4. In some years, small combine did not finish enough annual working area to reduce the operating cost because of its low capacity. For long-term development, the operator's wage will increase hastilly because of the rapidly development of industry. The annual interest rate graduately reduce at governmental bank to promote the overall mechanization of rice production. Larger combines will be more economical.

Table 4. The required working days of rice combine

Types	Capacity (ha/hr)	Working Areas 30	(ha/years) 50
YS —1300	0.094	43	71
MC—2250	0.177	23	38
TC —3500	0.256	16	26

CONCLUSION

In order to study the effect of two working patterns on efficiency of rice combines, a series of working locus equations were established. The working efficiency and cap acity were defined under the conditions of the area of paddy field, the type of machine ry, and the working patterns. As the field area was less than 0.4ha, circuitous method was better. At the range of 0.4—0.5ha, either pattern could be adopted. Continuous pattern was good for larger area.

Operating capacity and purchase price were the major deterimining factors for operating cost. From the view point of long-term development, larger combined will be more economical.

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水稻聯合收穫機作業方式、能力、與成本之研究[1]

陳 加 忠[2]

摘 要

在此研究中，以聯合收穫機的行走軌跡建立各項方程式以解析作業效率和能力與作業方式之關係，和決定各項影響因子。利用田間調查資料以研究最佳作業方式。調查結果顯示小田區以迴繞法較好，大田區作業以往復法爲主。作業面積0.4—0.5公頃時，兩者方法都可適用。由作業成本研究顯示，作業能力和農機售價是使用成本的主要決定因素。以長期經濟發展觀點，大型農機更爲合算。

1.臺灣省農業試驗所研究報告 1440 號。本文依作者於1988年美國農業工程學會夏季年會發表之論文 (ASAE Paper No. 88-5009) 補充資料，改寫而成。

2.本所農機系副研究員。臺灣省 臺中縣 霧峰鄉。

中華農業研究

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